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Hayashi et al.

(10) **Patent No.: US 8,692,455 B2**
(45) **Date of Patent: Apr. 8, 2014**

(54) **DISPLAY DEVICE AND METHOD FOR PRODUCTION THEREOF**

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(73) Assignee: **Sony Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 279 days.

(21) Appl. No.: **12/330,194**

(22) Filed: **Dec. 8, 2008**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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May 9, 2008 (JP) 2008-123004

(51) **Int. Cl.**
H05B 33/26 (2006.01)

(52) **U.S. Cl.**
USPC **313/506**; 313/504

(58) **Field of Classification Search**
USPC 313/504, 506
See application file for complete search history.

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(74) *Attorney, Agent, or Firm* — Dentons US LLP

(57) **ABSTRACT**

A display device having a plurality of driving elements and wiring parts electrically connected to the driving parts, the display device includes: a plurality of first electrodes which are formed in correspondence to each driving element on the driving elements and the wiring parts; a plurality of light-emitting parts which are each formed on the first electrodes; a common second electrode which is formed from a material that transmits light from the light-emitting part and is formed on the light-emitting parts; auxiliary wiring parts with a lower resistance than the second electrodes; and contact parts which are formed in laminate structure from a plurality of conductive layers and which electrically connect the second electrodes and the auxiliary wirings with each other, with at least the lowermost conductive layer of the conductive layers of the contact parts being in direct contact with the second electrode.

13 Claims, 24 Drawing Sheets

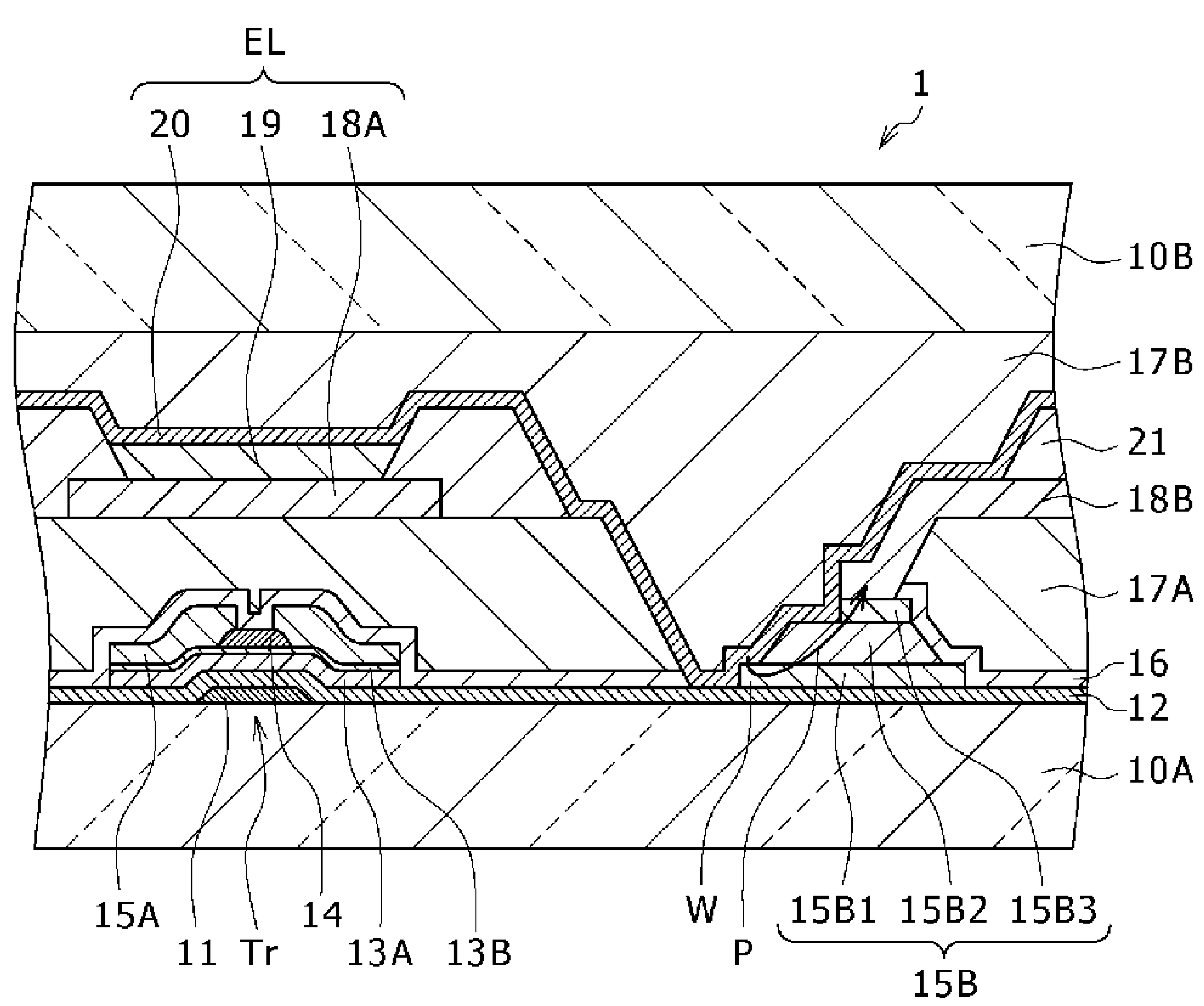


FIG. 1

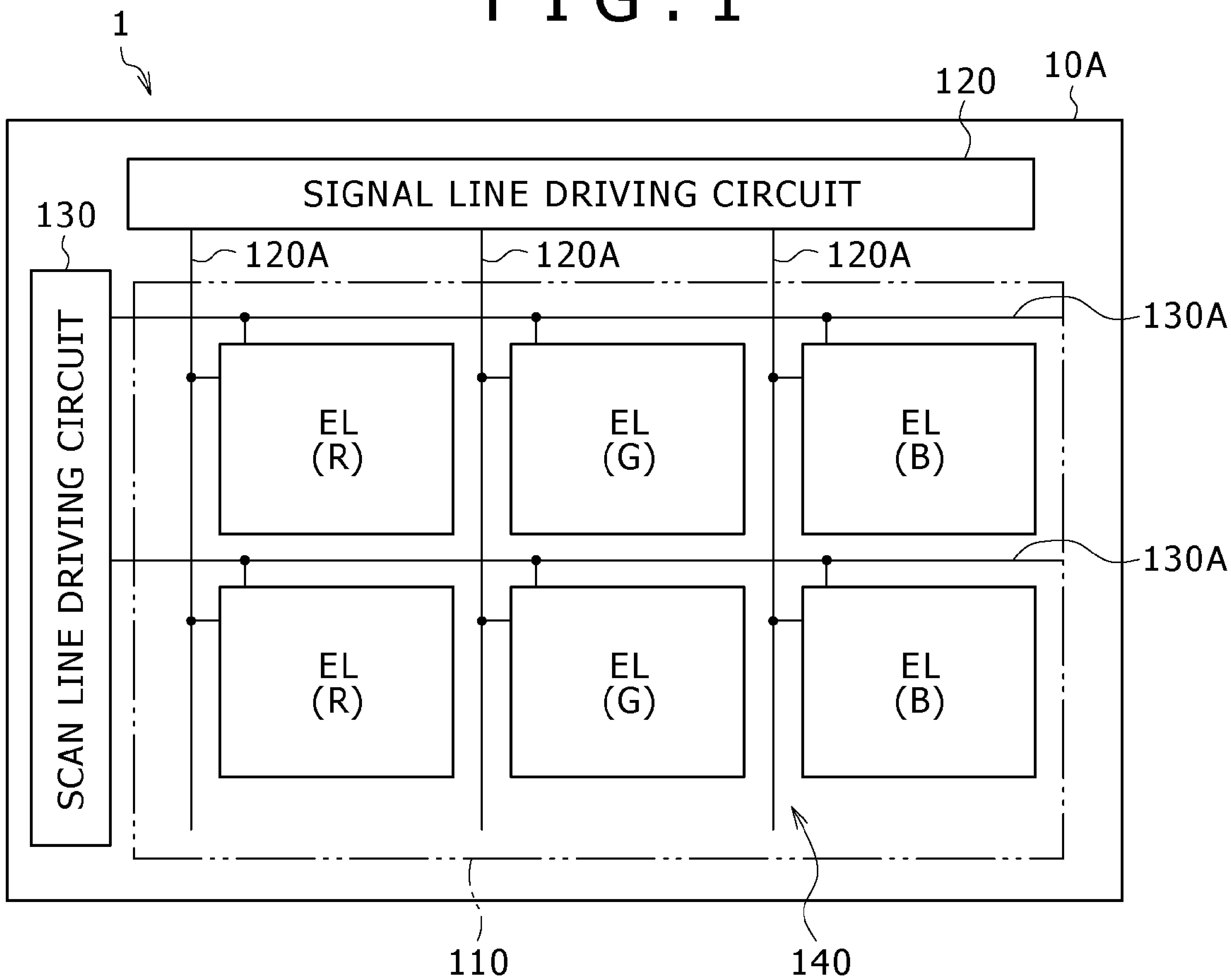

1
120
10A
SIGNAL LINE DRIVING CIRCUIT
130
120A
120A
120A
130A
SCAN LINE DRIVING CIRCUIT
EL (R)
EL (G)
EL (B)
130A
EL (R)
EL (G)
EL (B)
110
140

FIG. 2

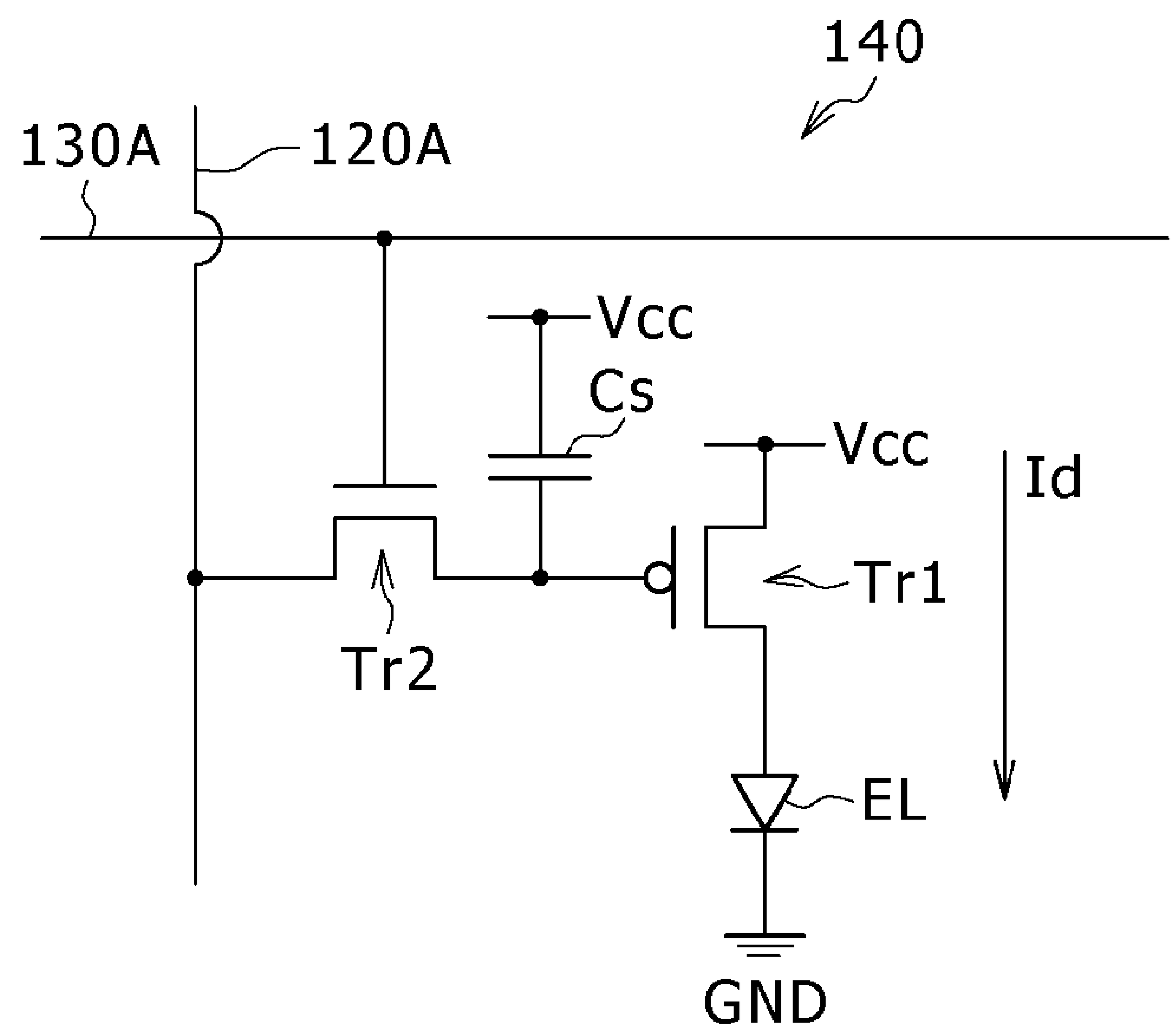

140
130A
120A
Vcc
Cs
Vcc
Id
Tr1
Tr2
EL
GND

FIG. 3

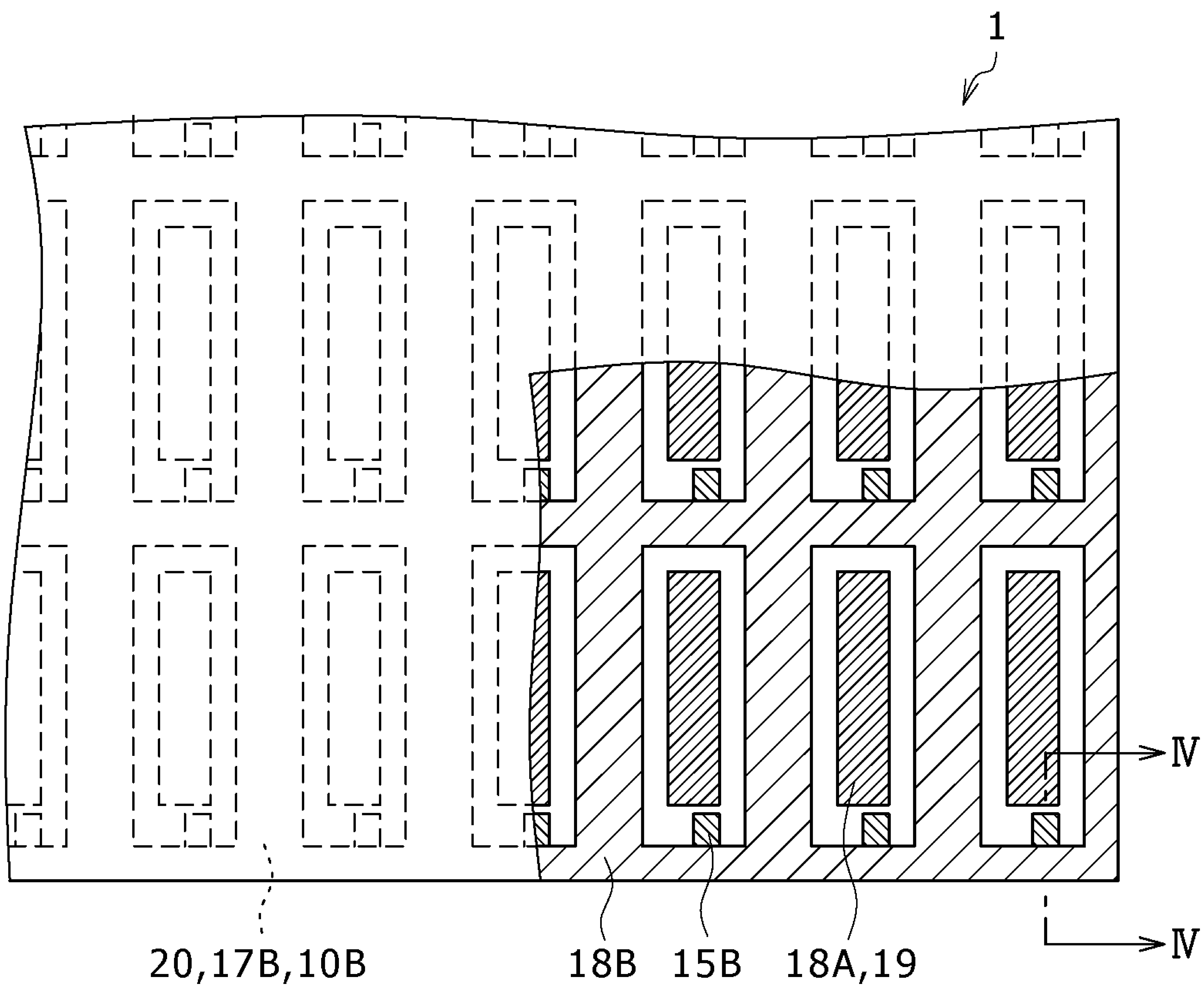


FIG. 4

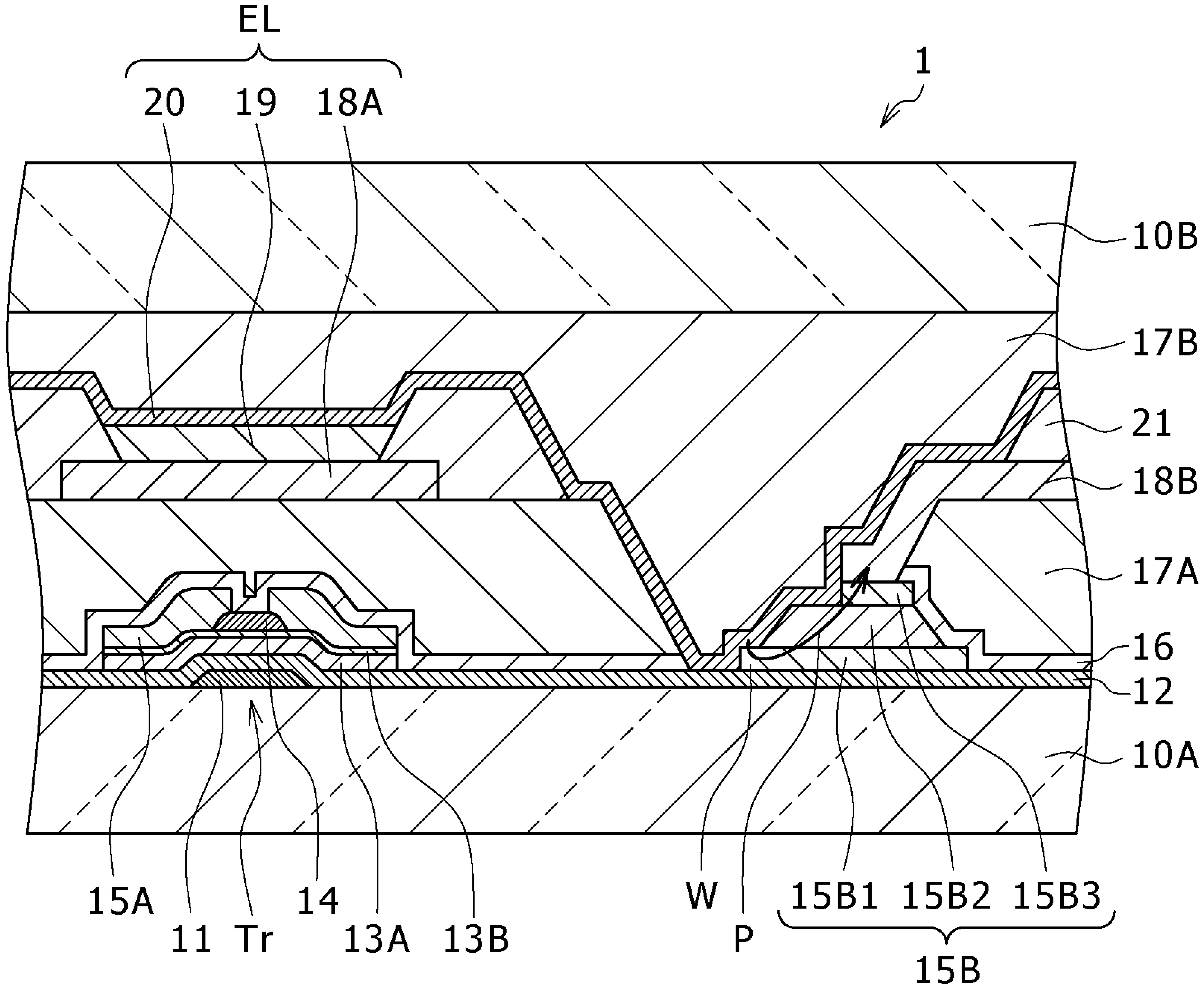

EL
20
19
18A
1
10B
17B
21
18B
17A
16
12
10A
15A
11
Tr
14
13A
13B
W
P
15B1
15B2
15B3
15B

FIG.5A

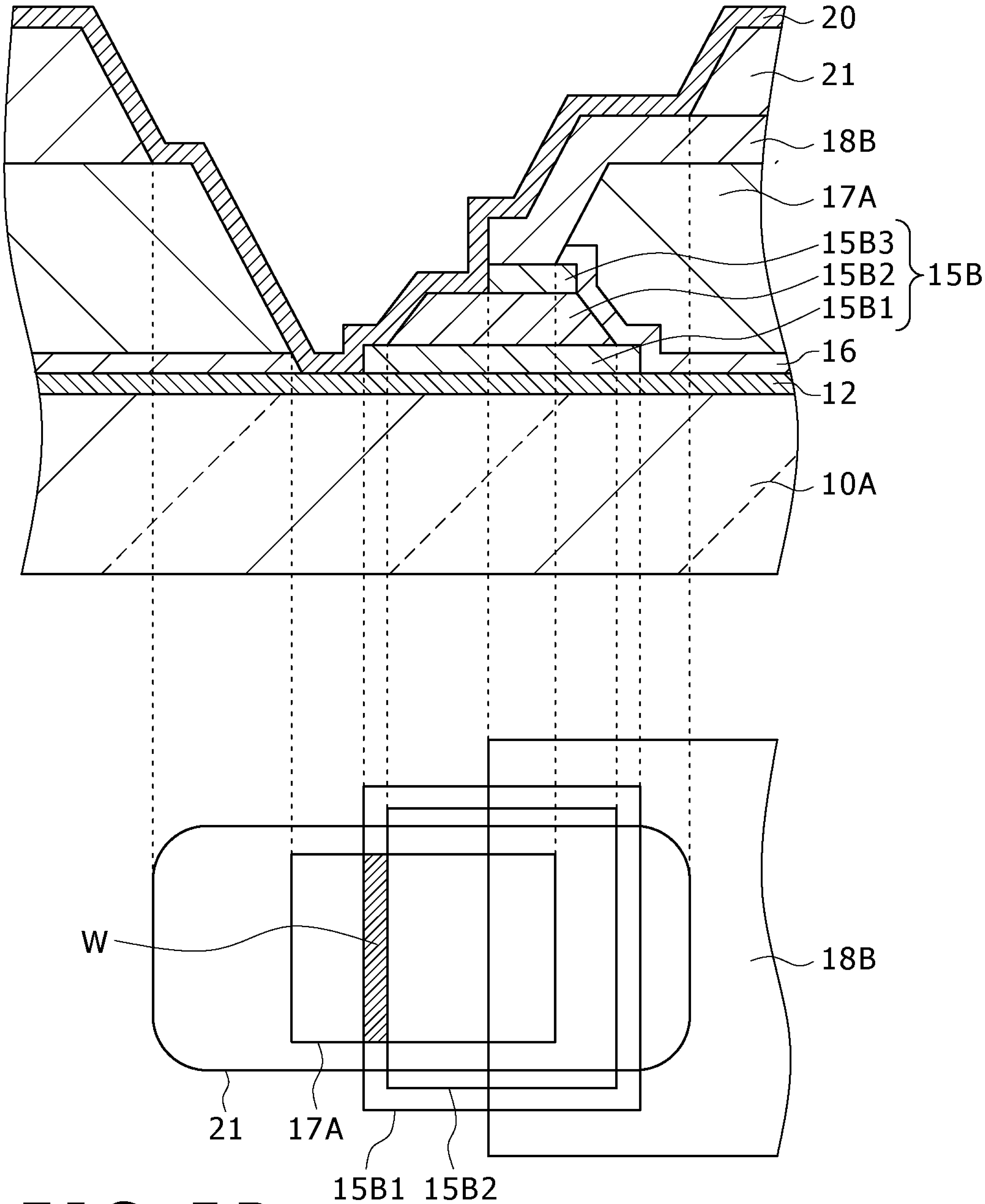


FIG.5B

FIG. 6

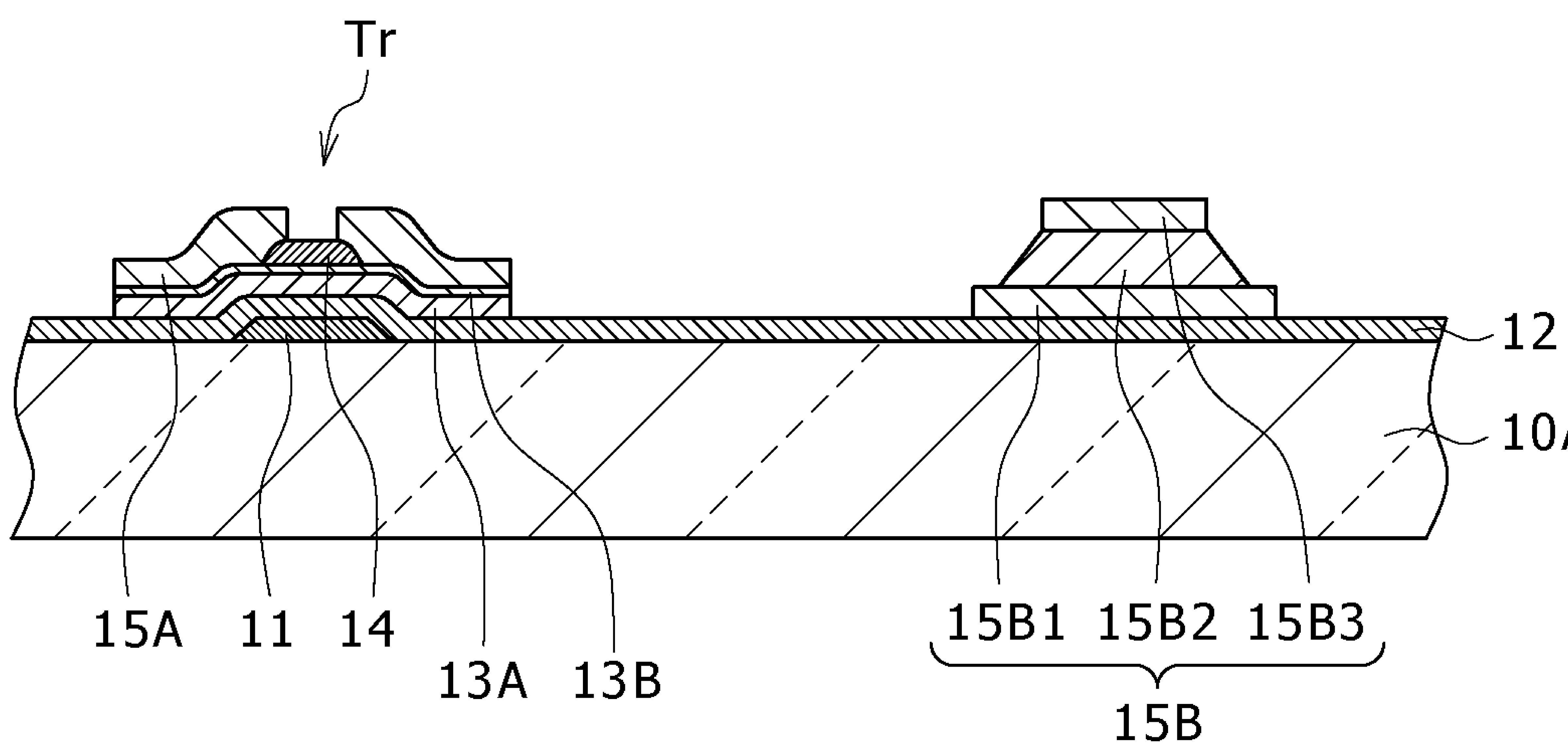


FIG.7A

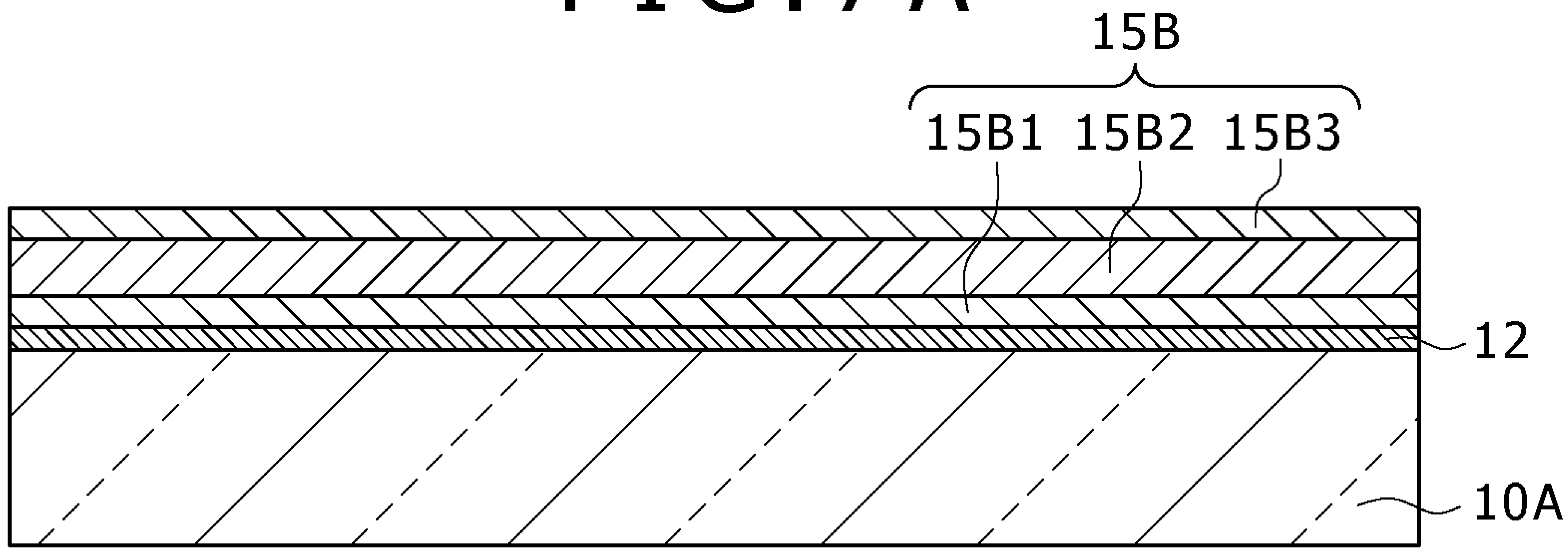


FIG.7B

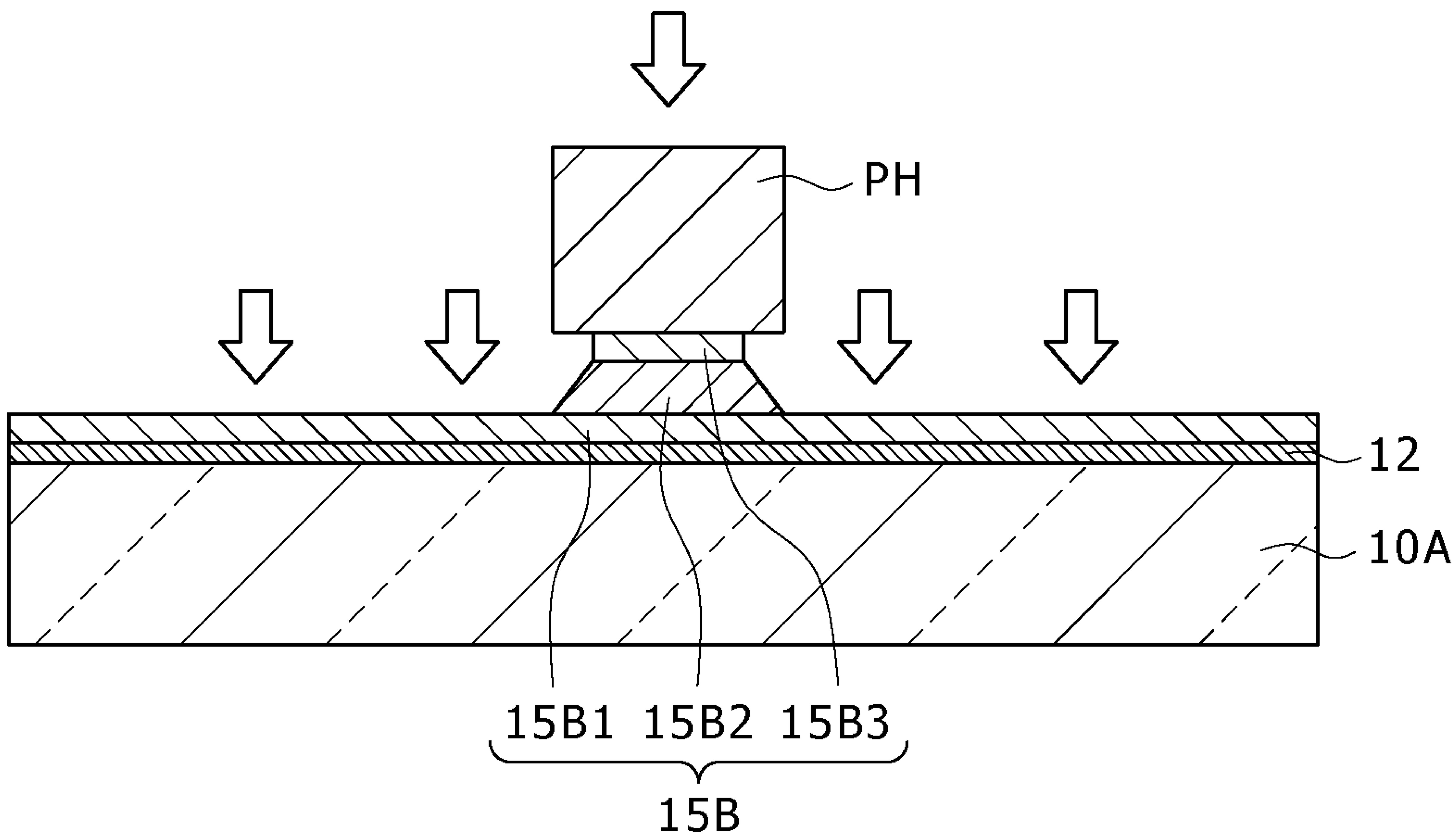


FIG.7C

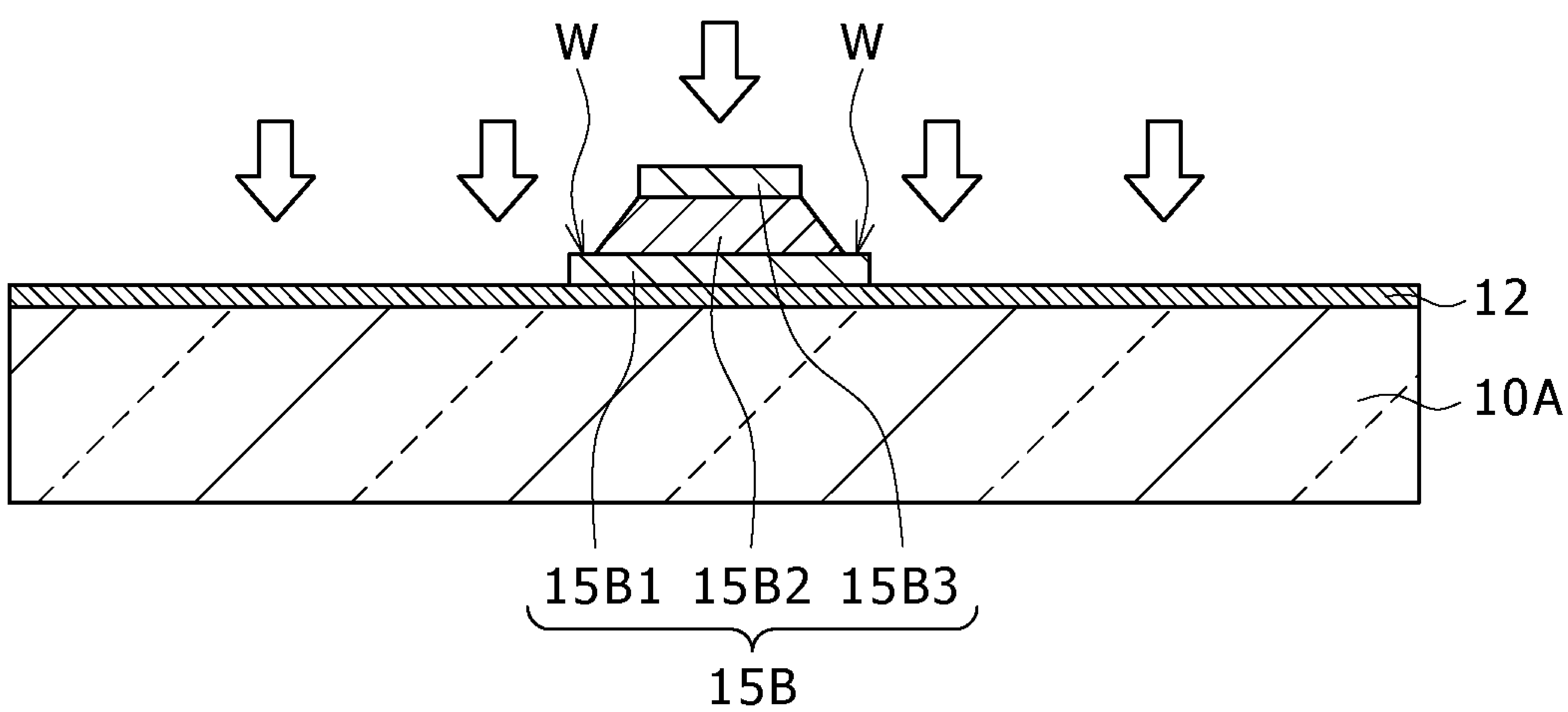


FIG.8A

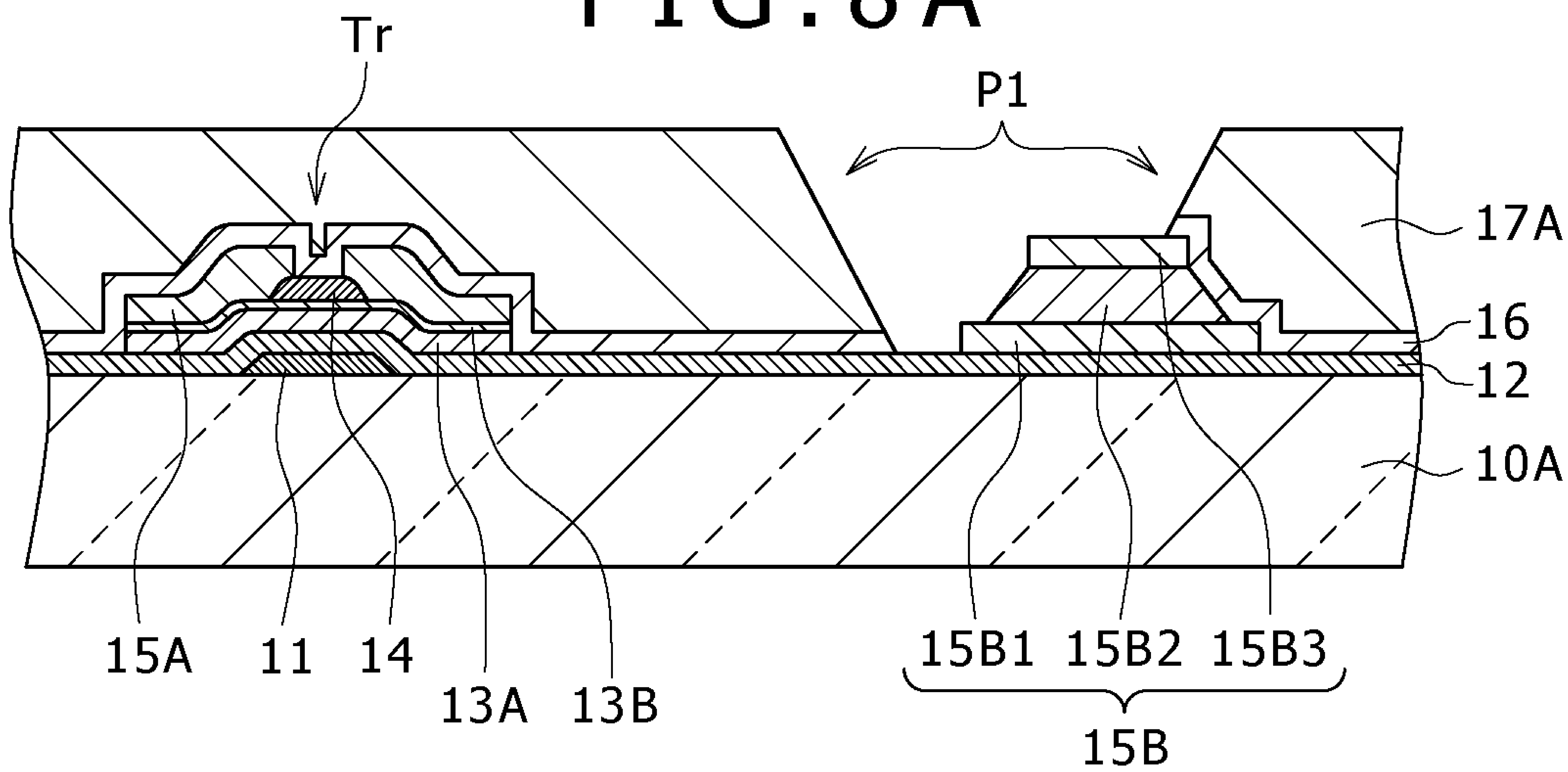


FIG.8B

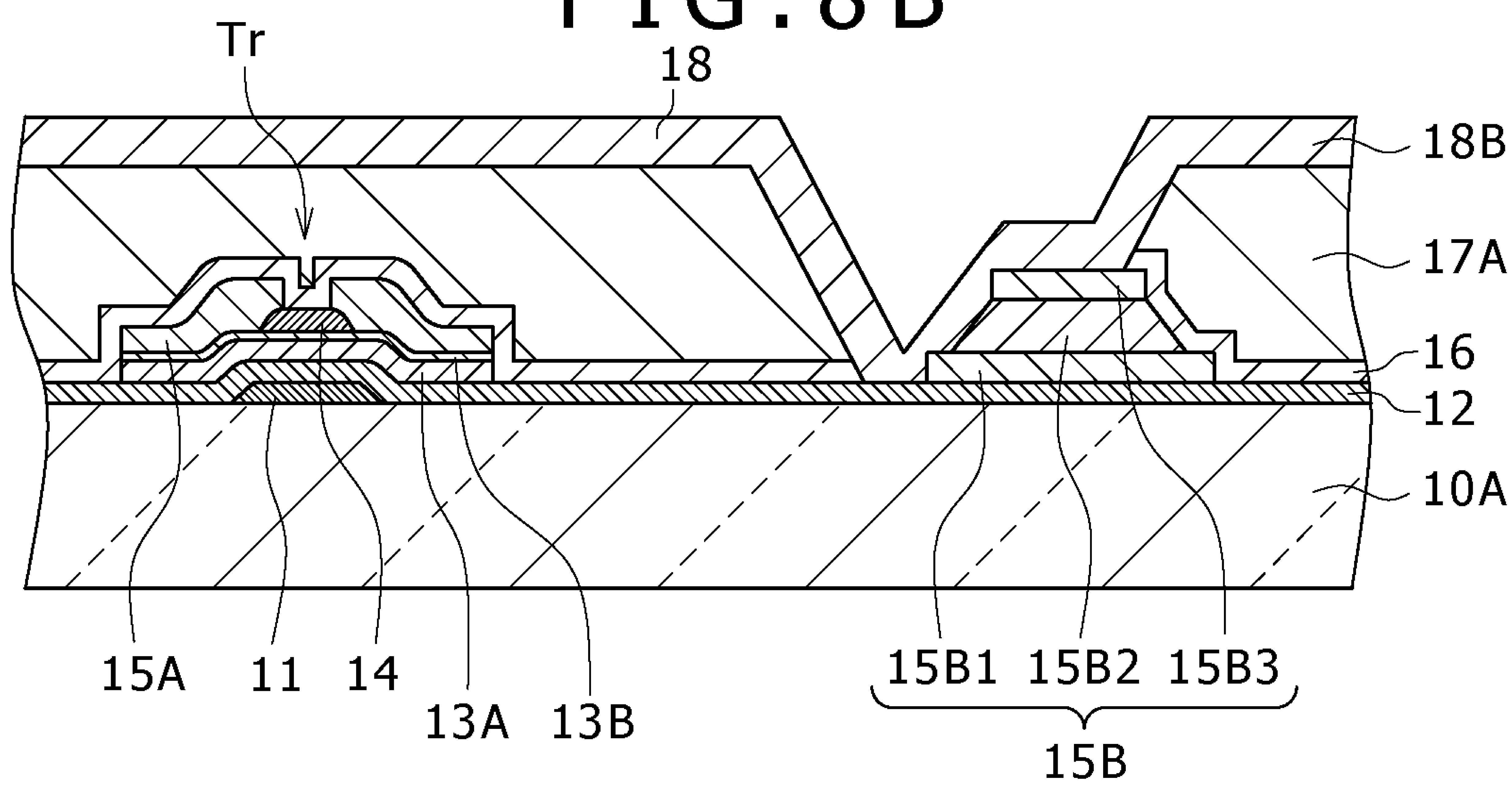


FIG.8C

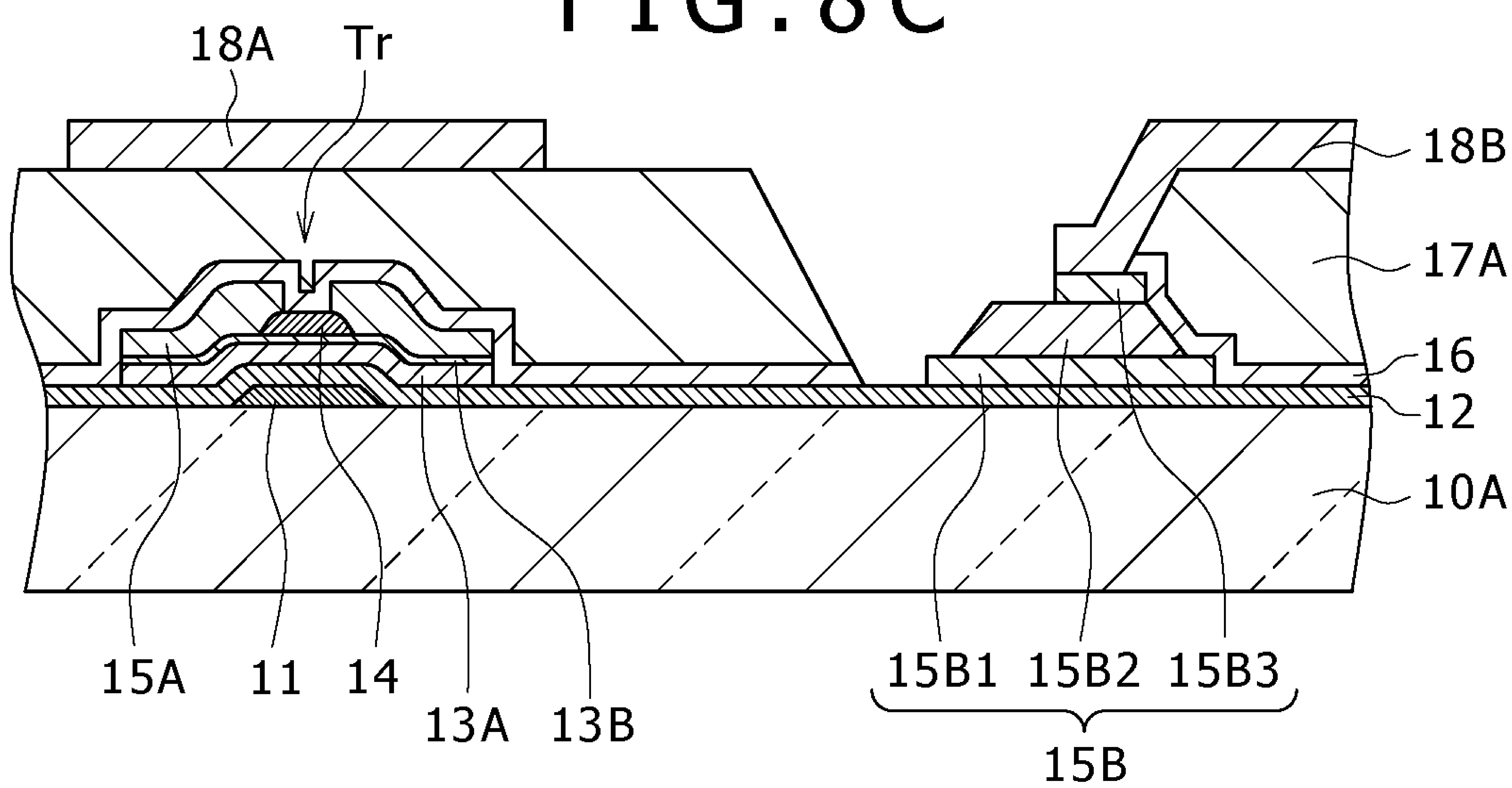


FIG. 9A

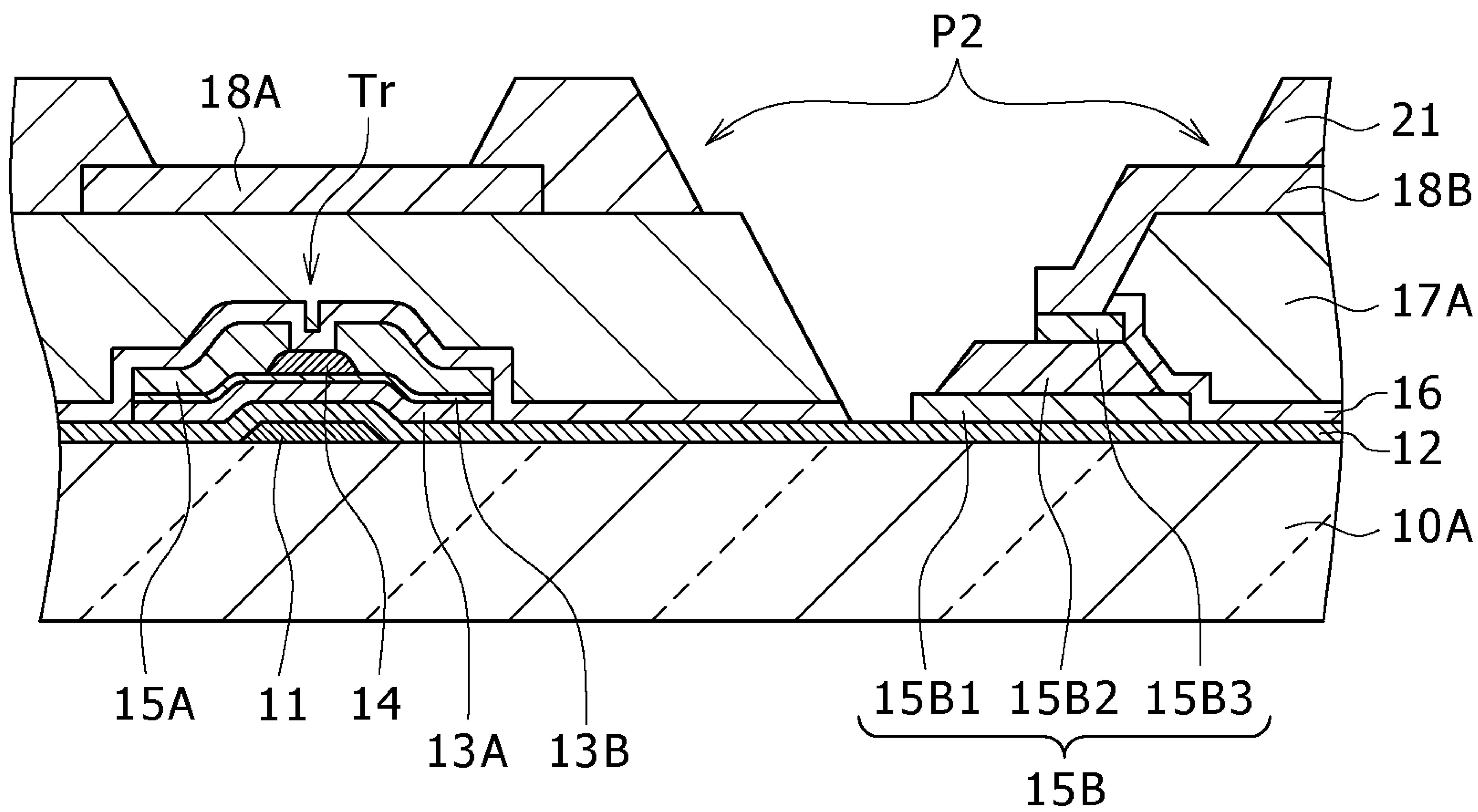

P2
18A
Tr
21
18B
17A
16
12
10A
15A
11
14
13A
13B
15B1
15B2
15B3
15B

FIG. 9B

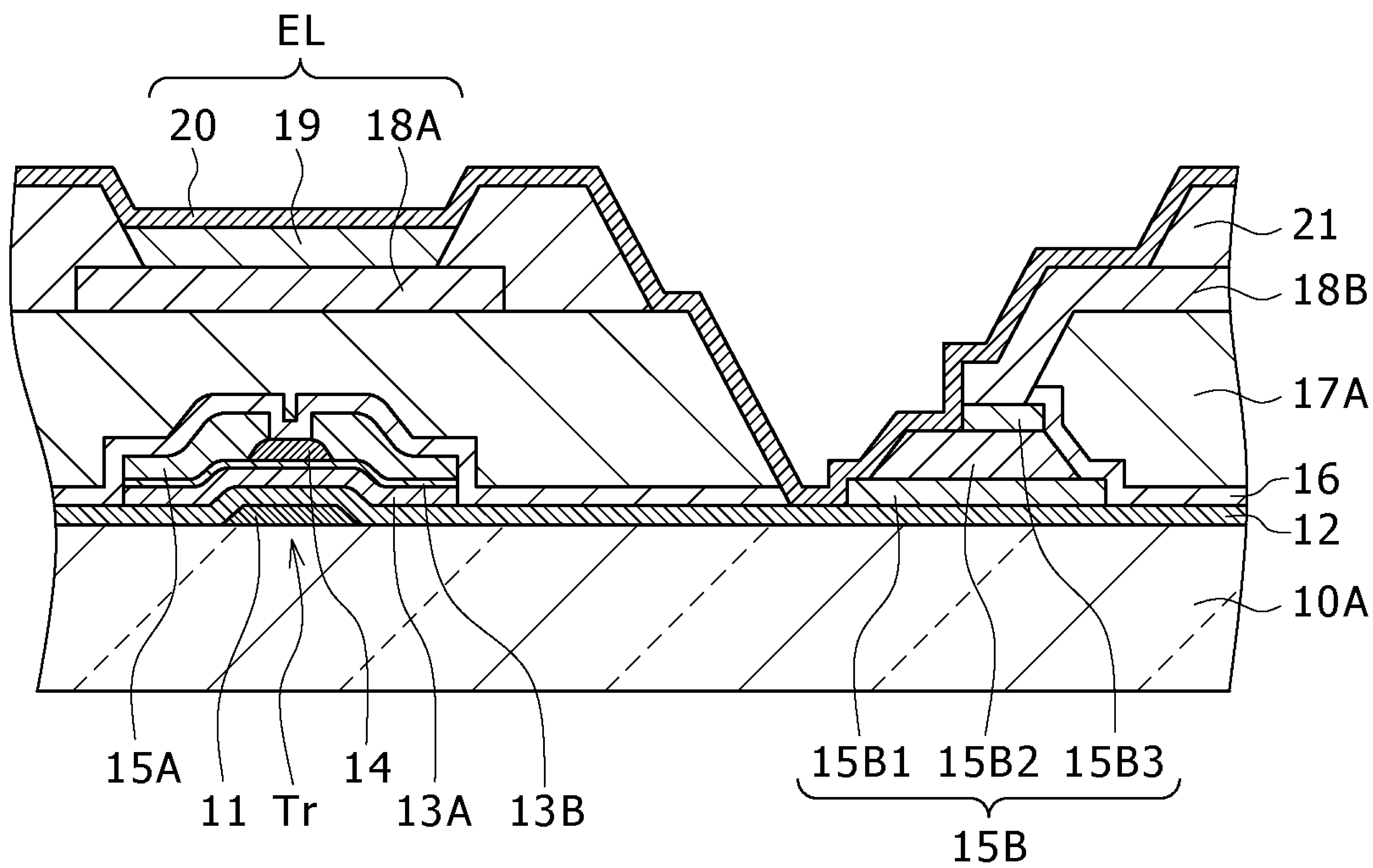

EL
20
19
18A
21
18B
17A
16
12
10A
15A
11
Tr
14
13A
13B
15B1
15B2
15B3
15B

FIG. 10

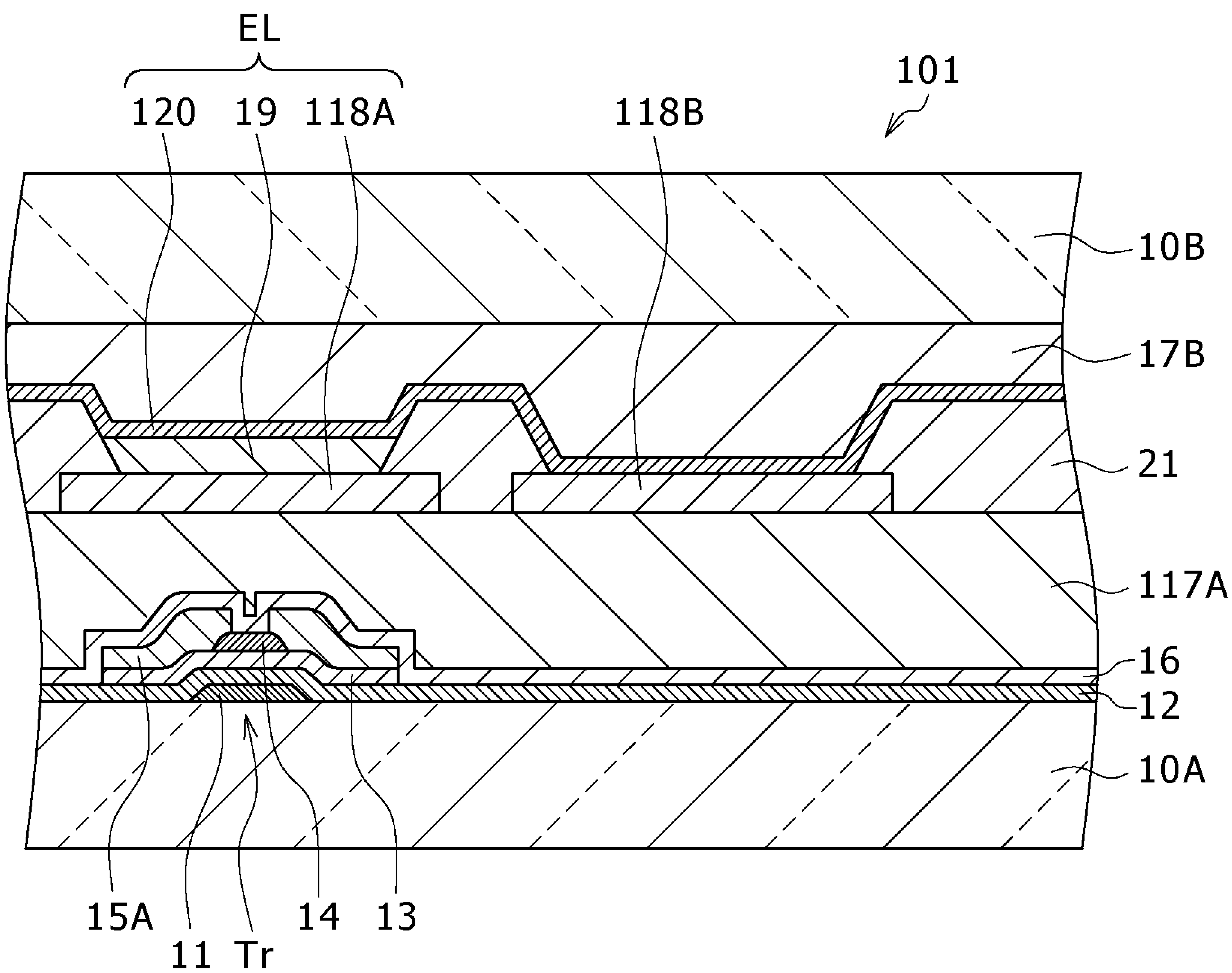


FIG. 11

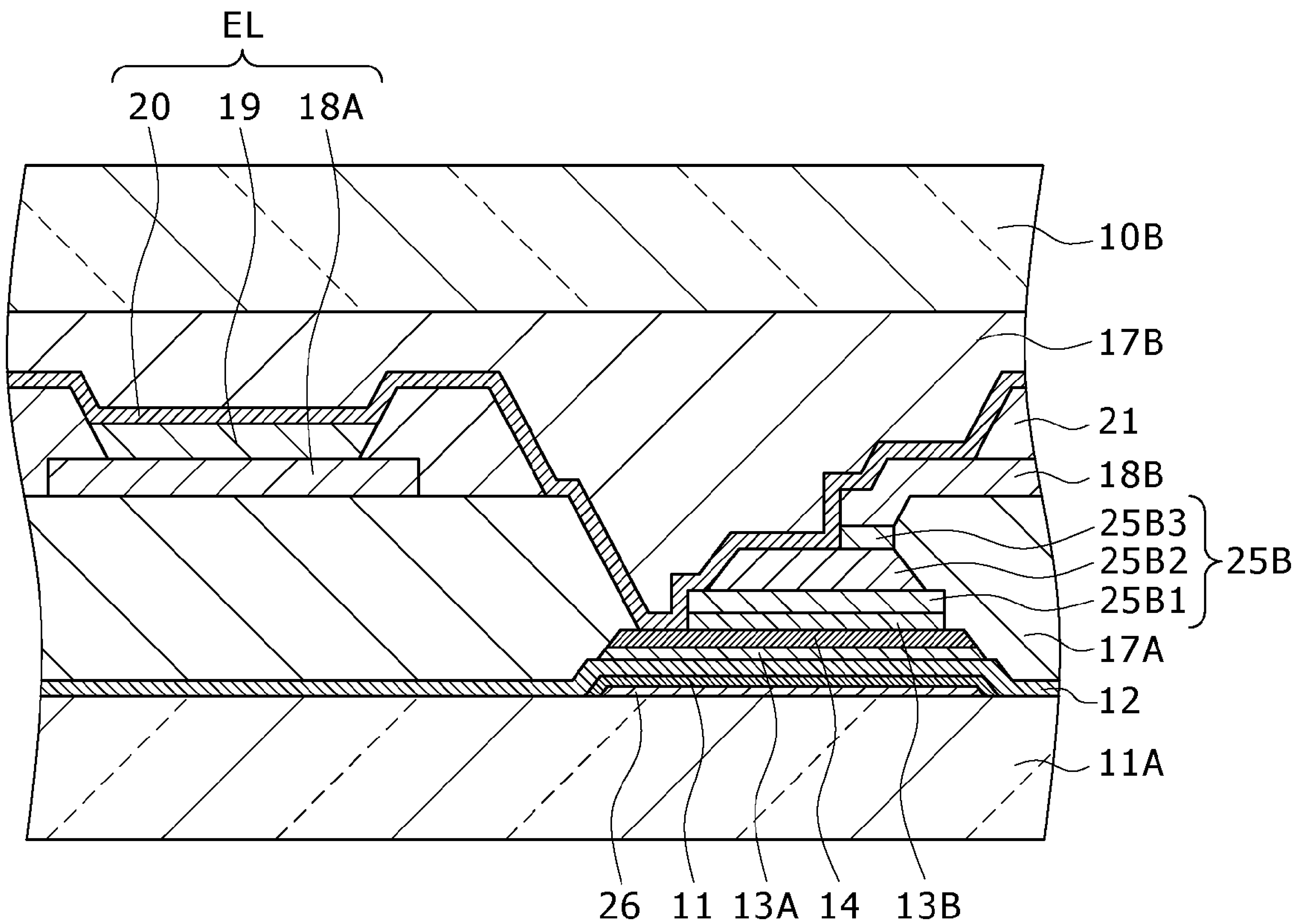
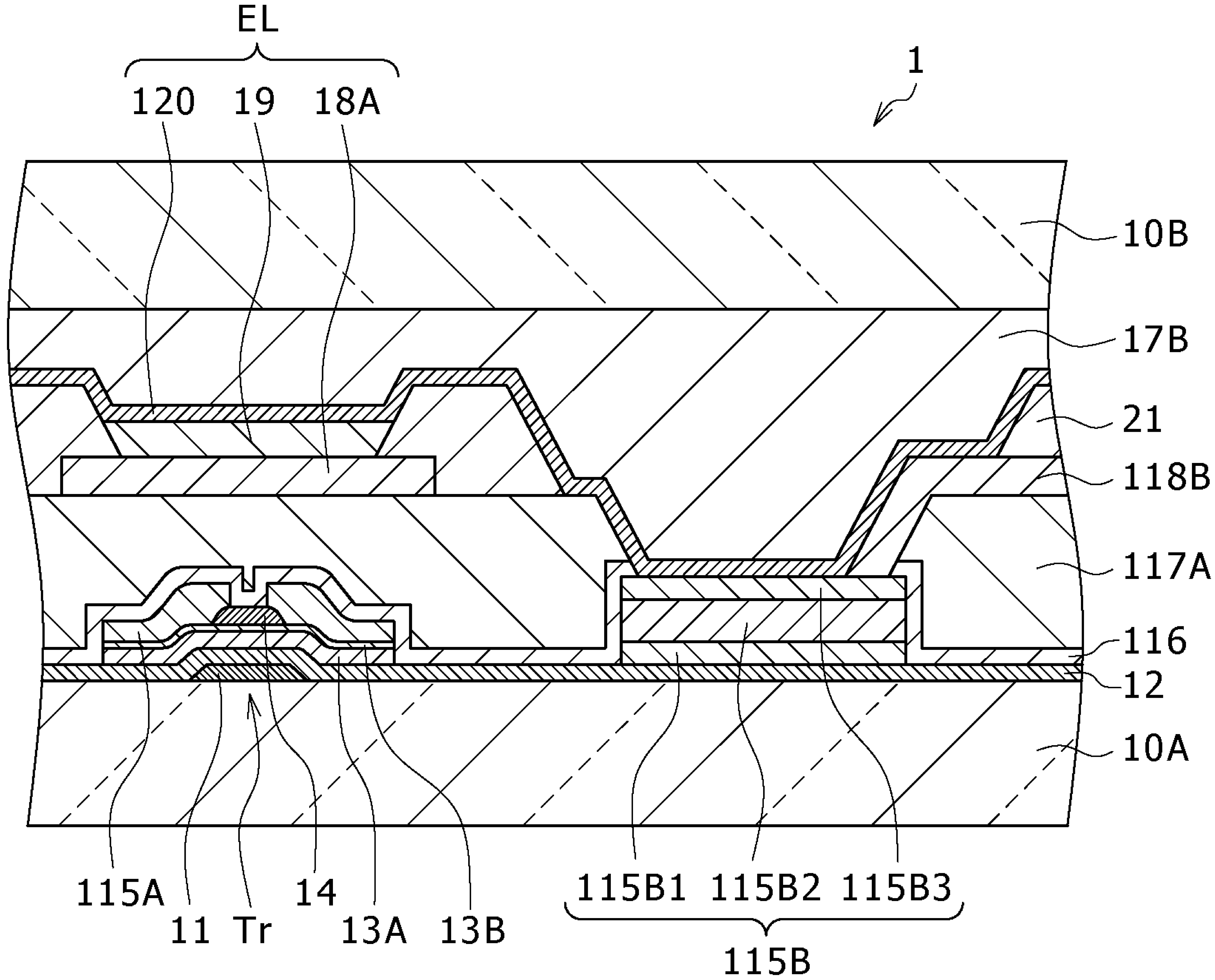

EL
20
19
18A
10B
17B
21
18B
25B3
25B2
25B1
25B
17A
12
11A
26
11
13A
14
13B

FIG.12


EL
120
19
18A
1
10B
17B
21
118B
117A
116
12
10A
115A
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Tr
14
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13B
115B1
115B2
115B3
115B

FIG.13

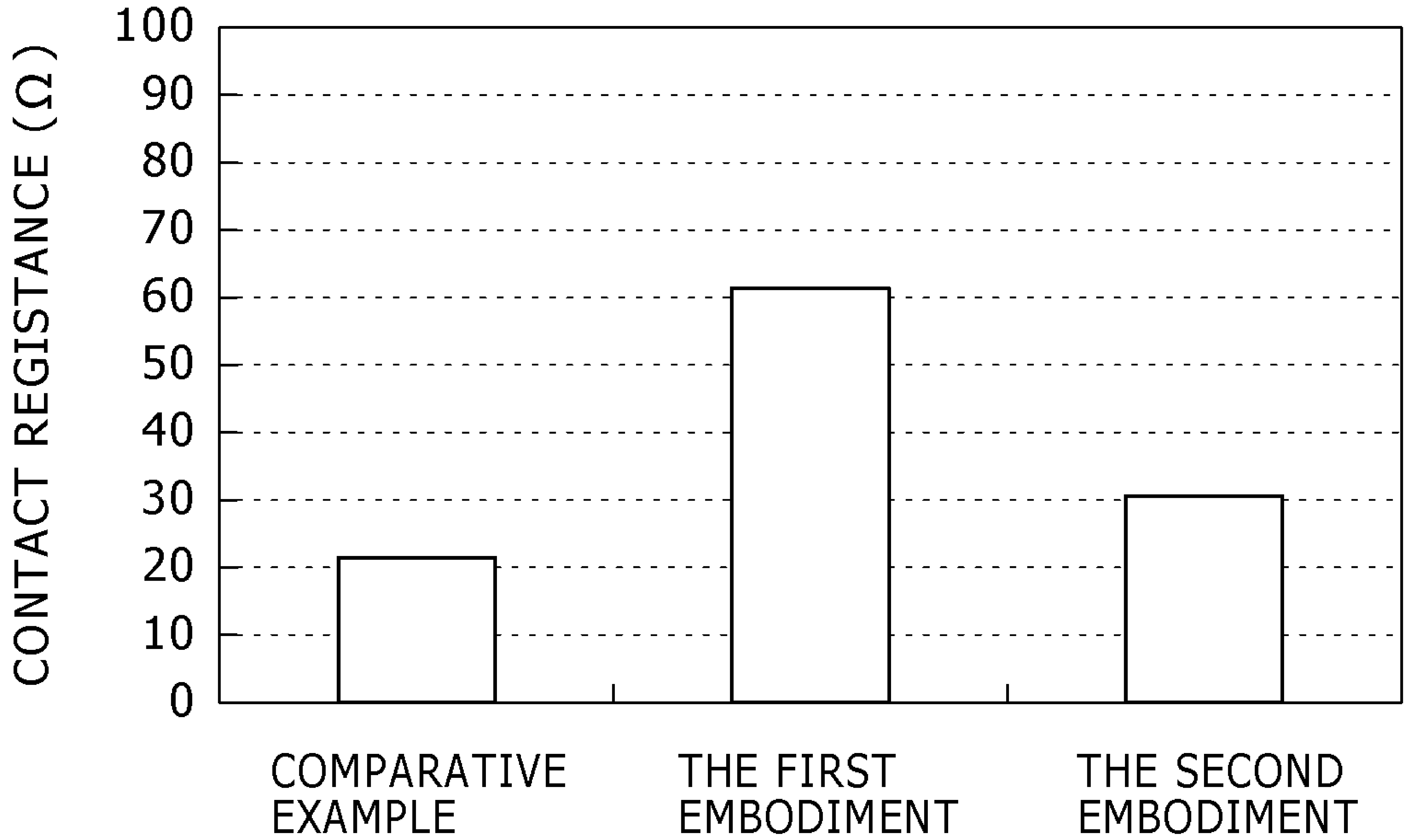

CONTACT REGISTANCE (Ω)
100
90
80
70
60
50
40
30
20
10
0
COMPARATIVE EXAMPLE
THE FIRST EMBODIMENT
THE SECOND EMBODIMENT

FIG.14

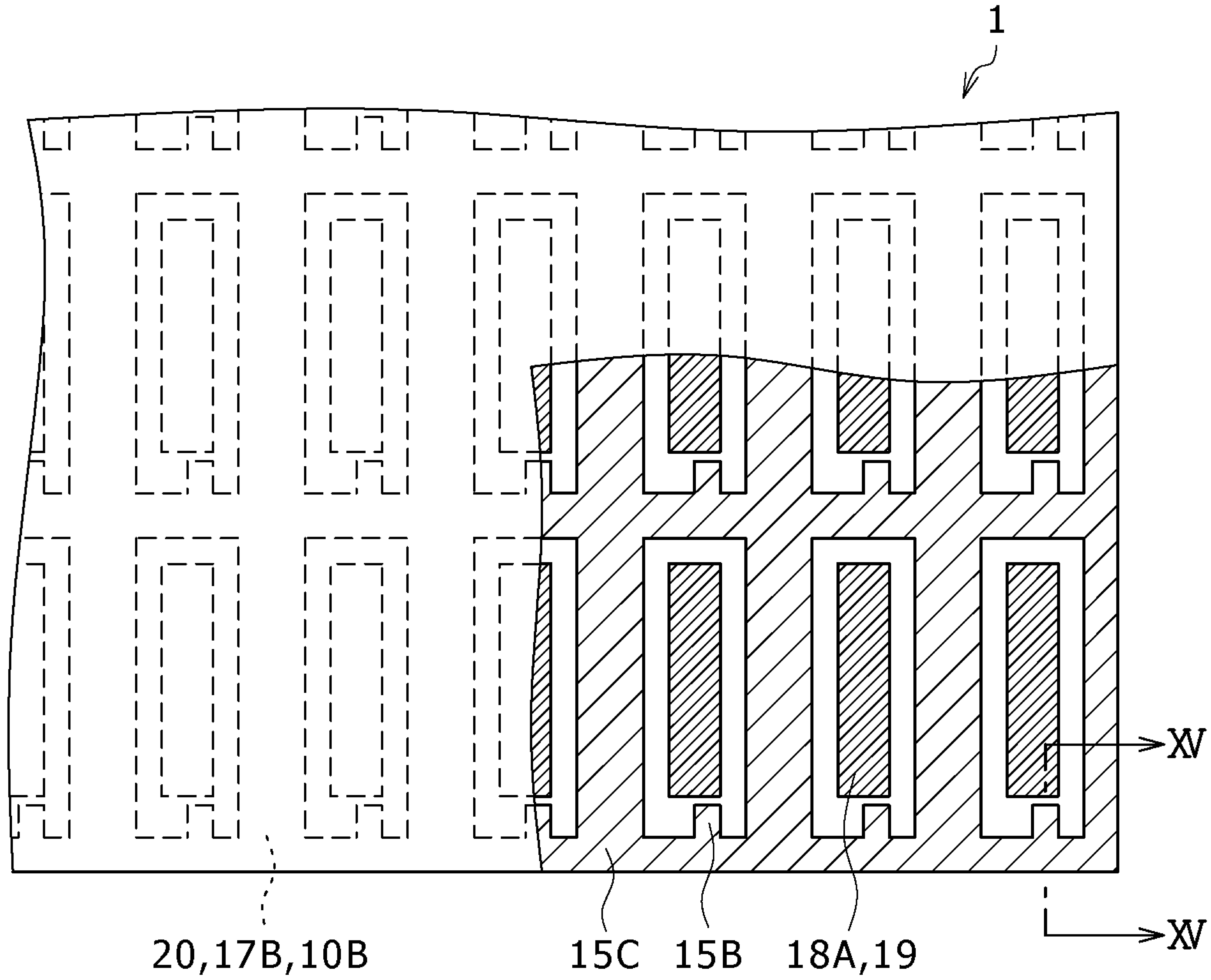
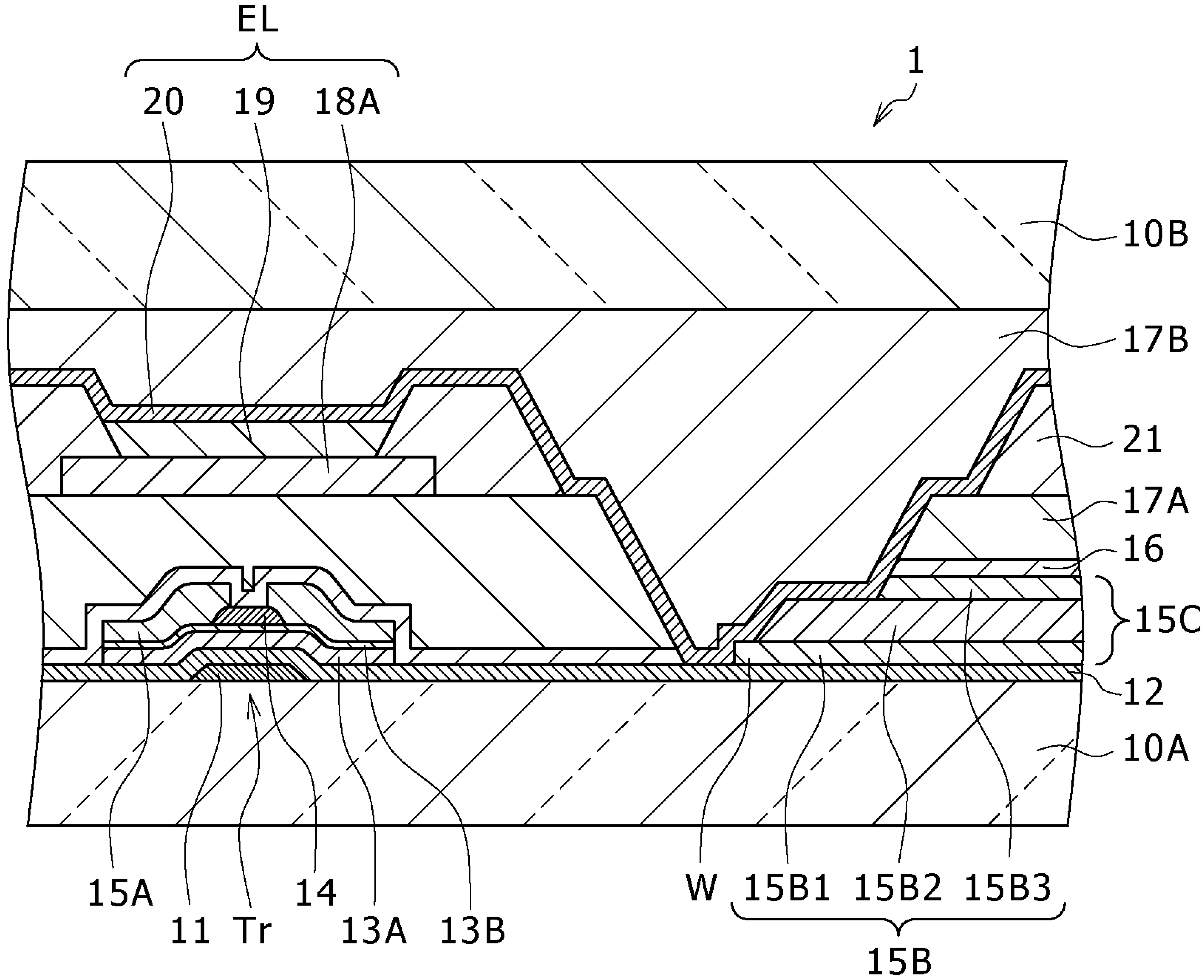


FIG.15


EL
20
19
18A
1
10B
17B
21
17A
16
15C
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15A
11
Tr
14
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13B
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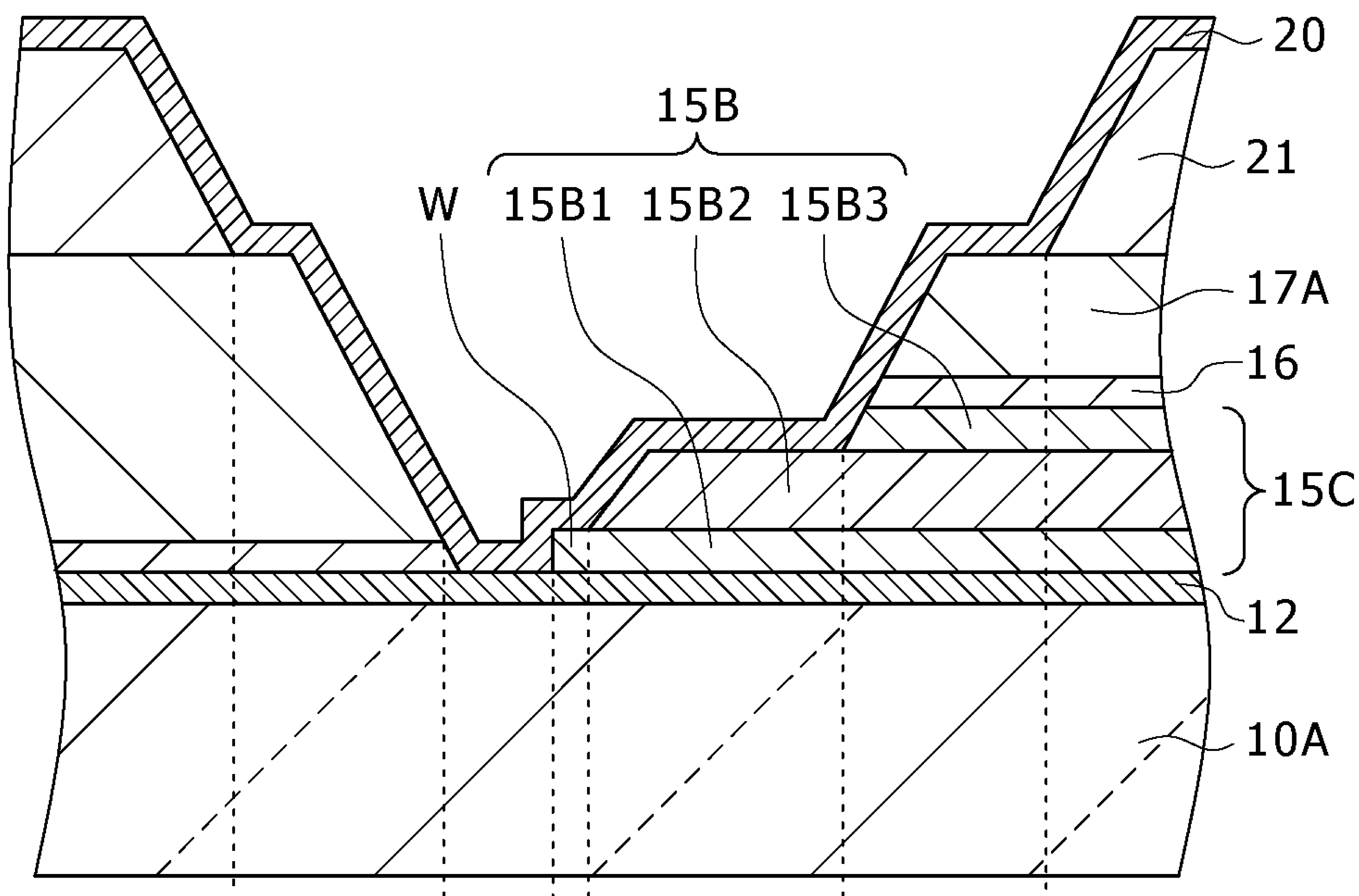
15B2
15B3
15B

FIG.16A



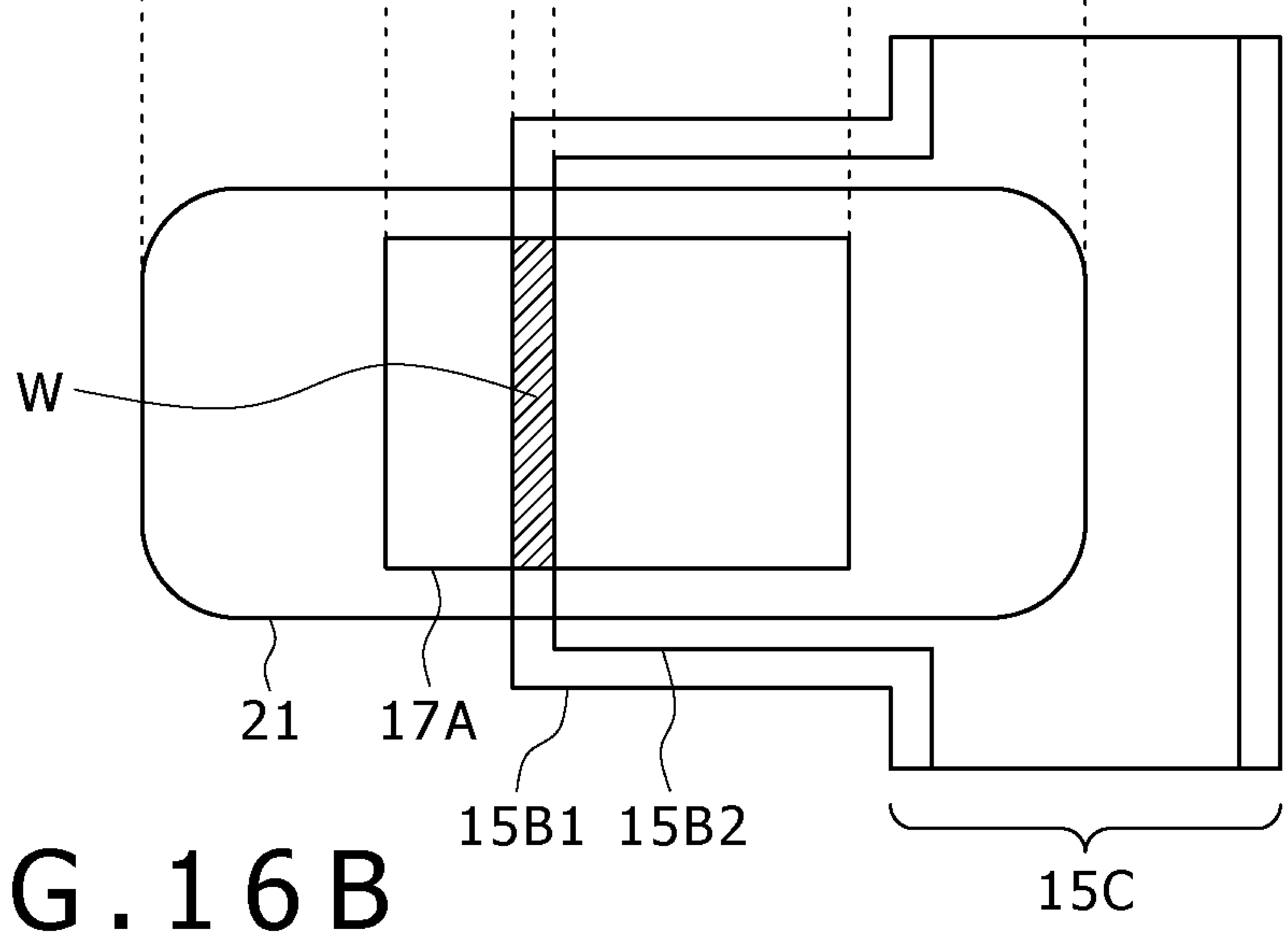


FIG.16B

FIG.17

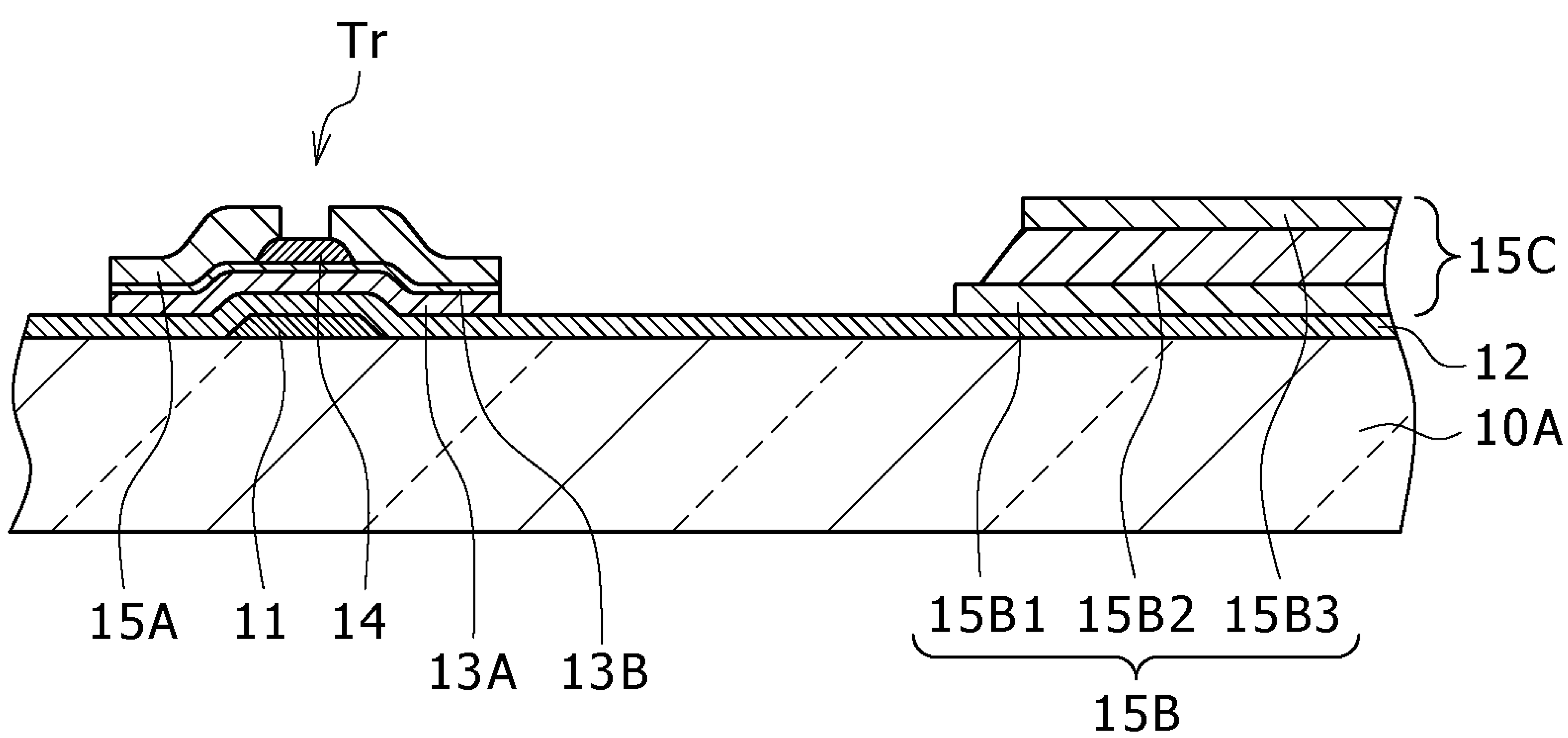


FIG. 18A

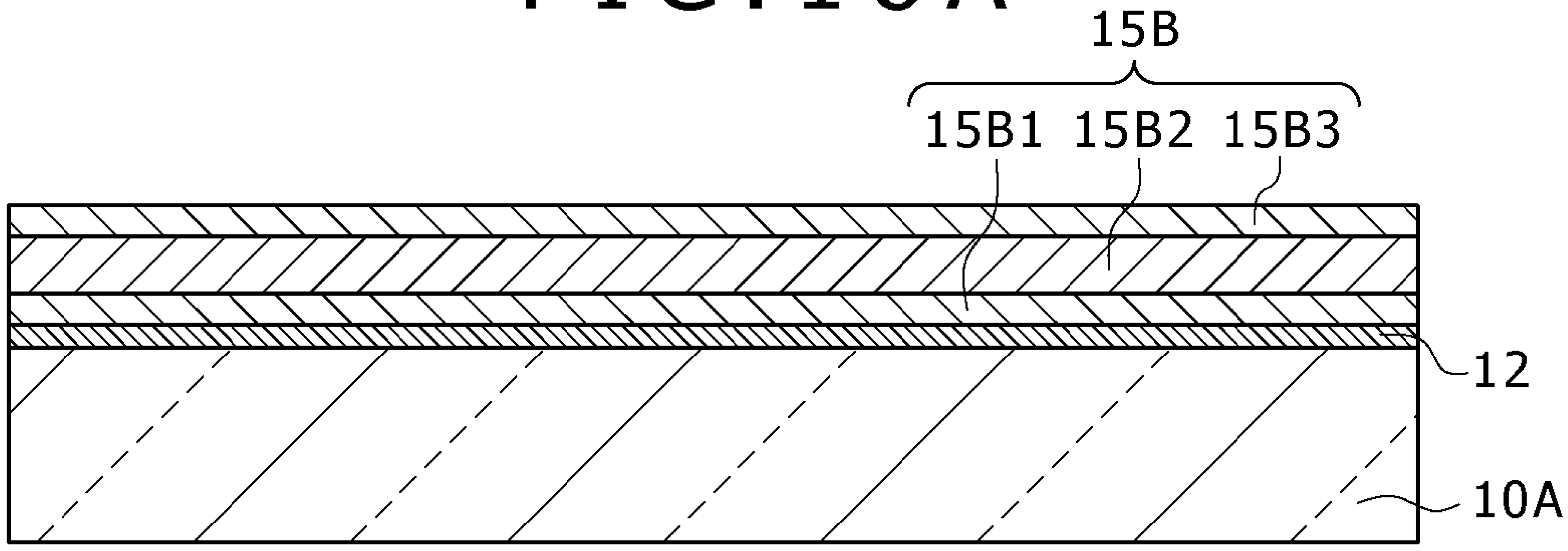


FIG. 18B

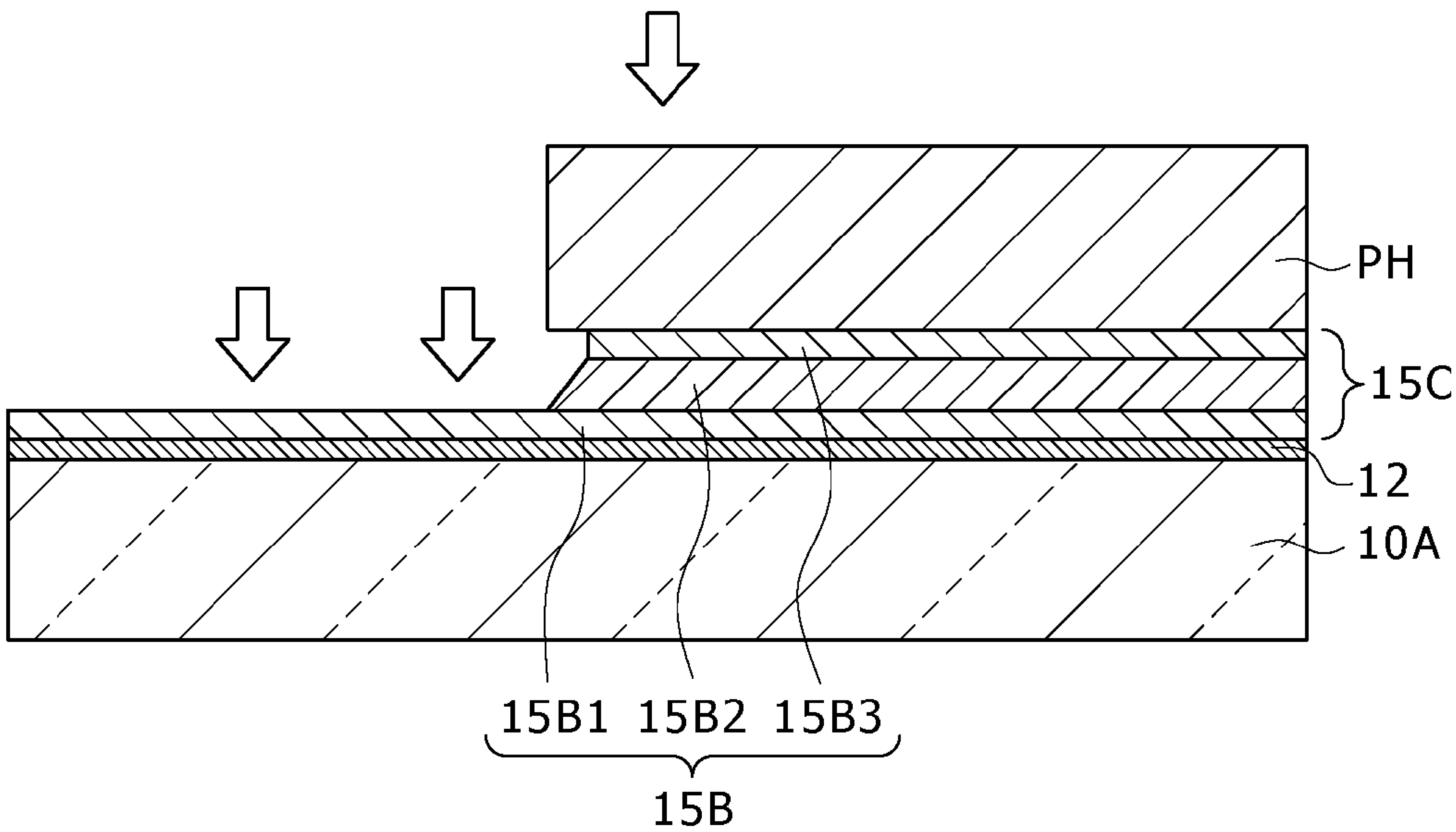


FIG. 18C

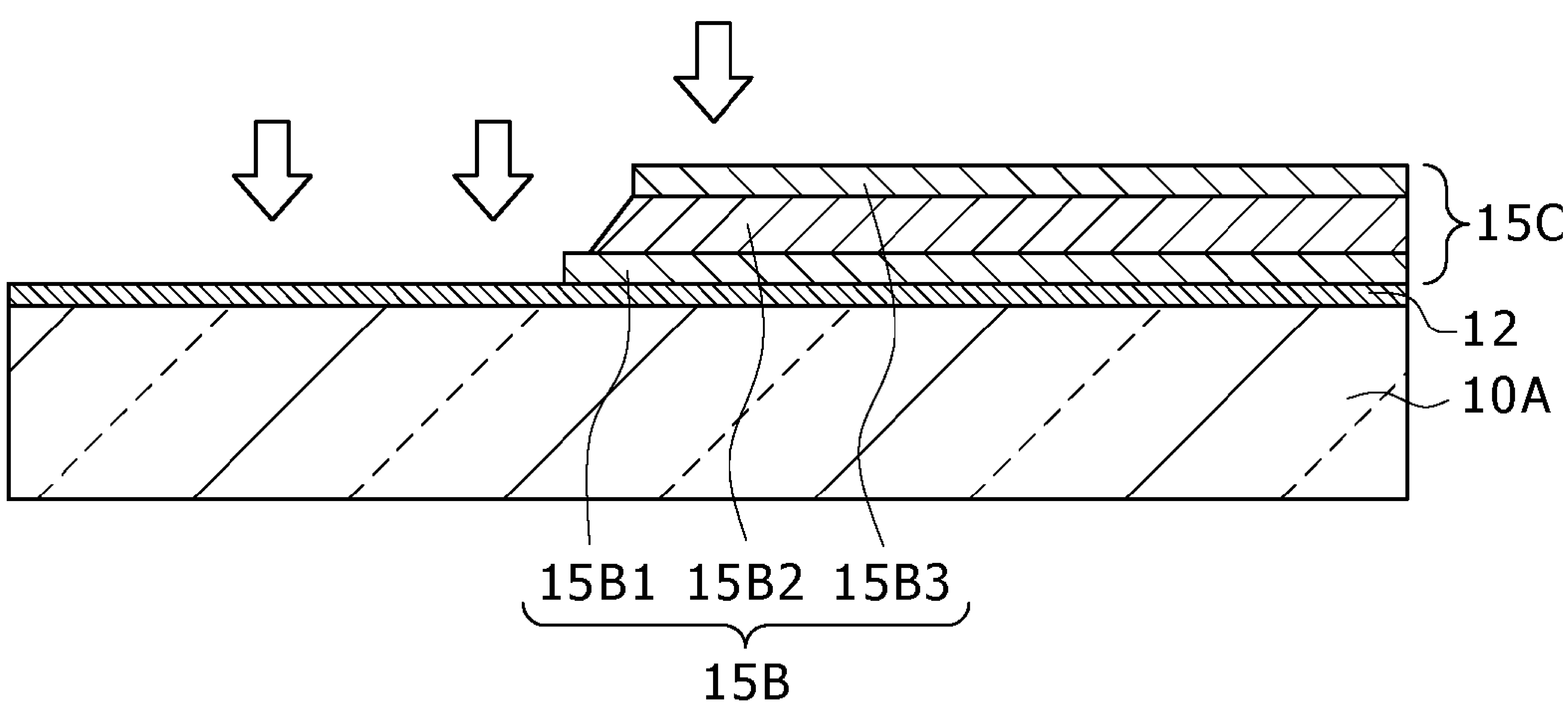


FIG.19A

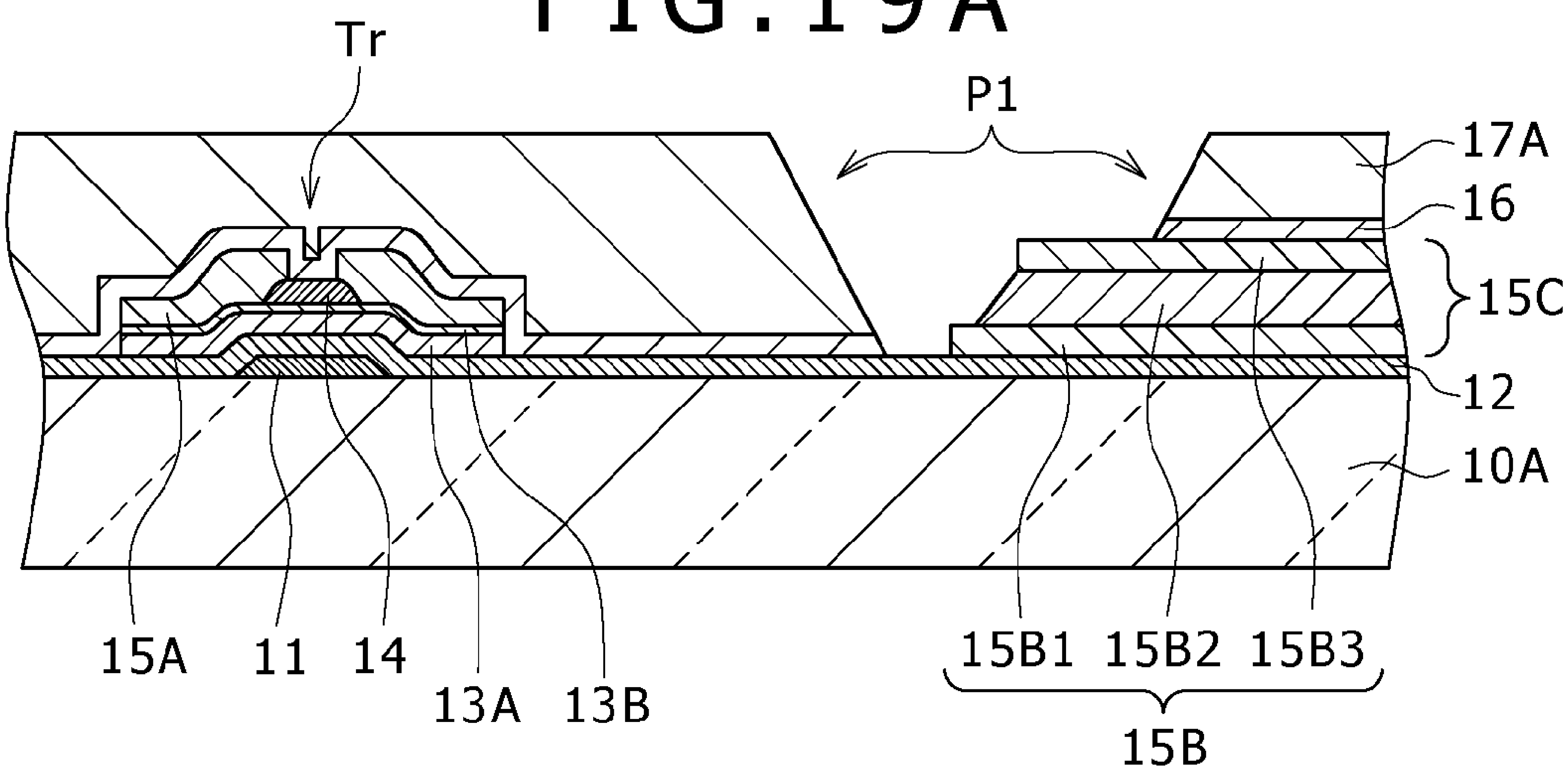


FIG.19B

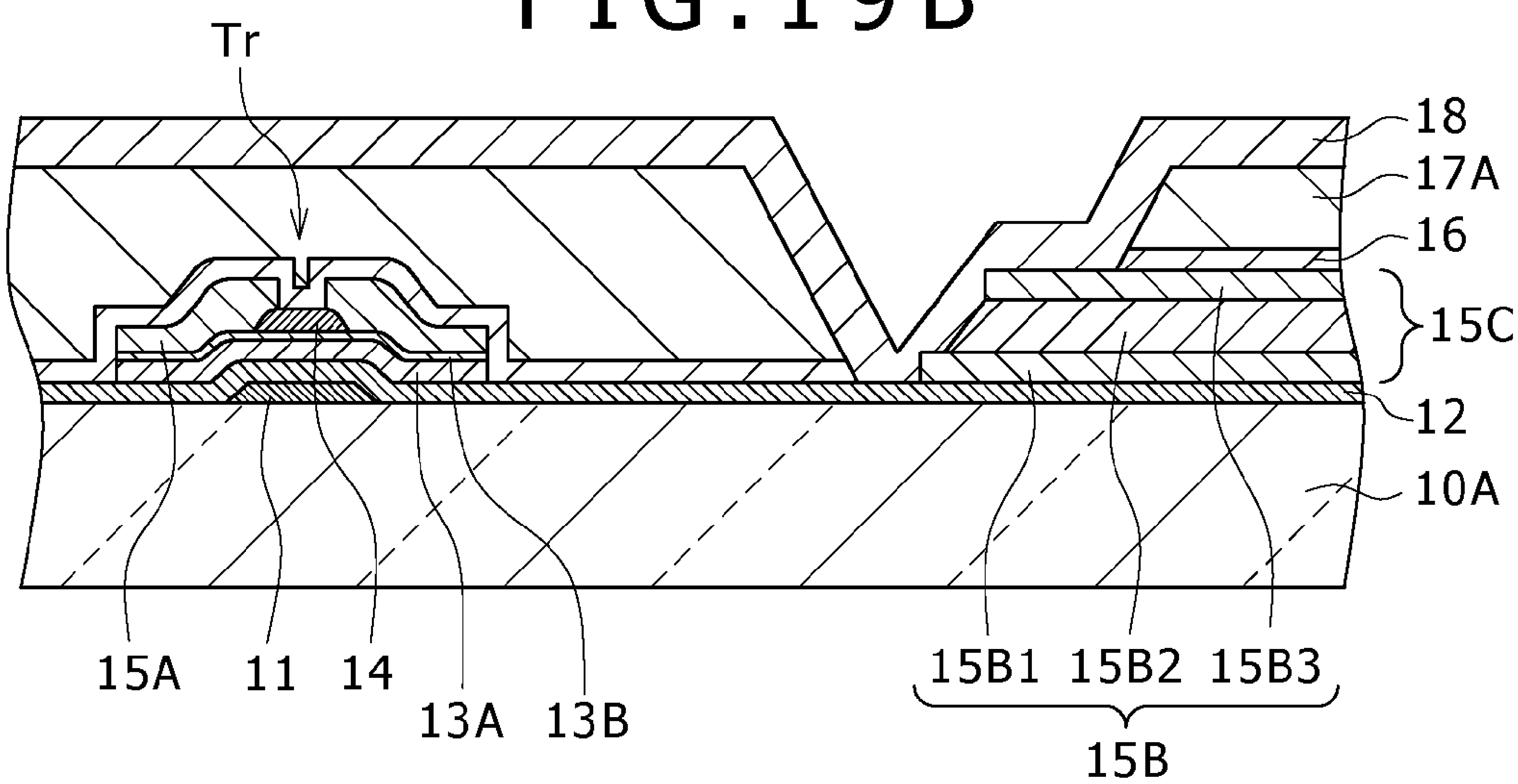


FIG.19C

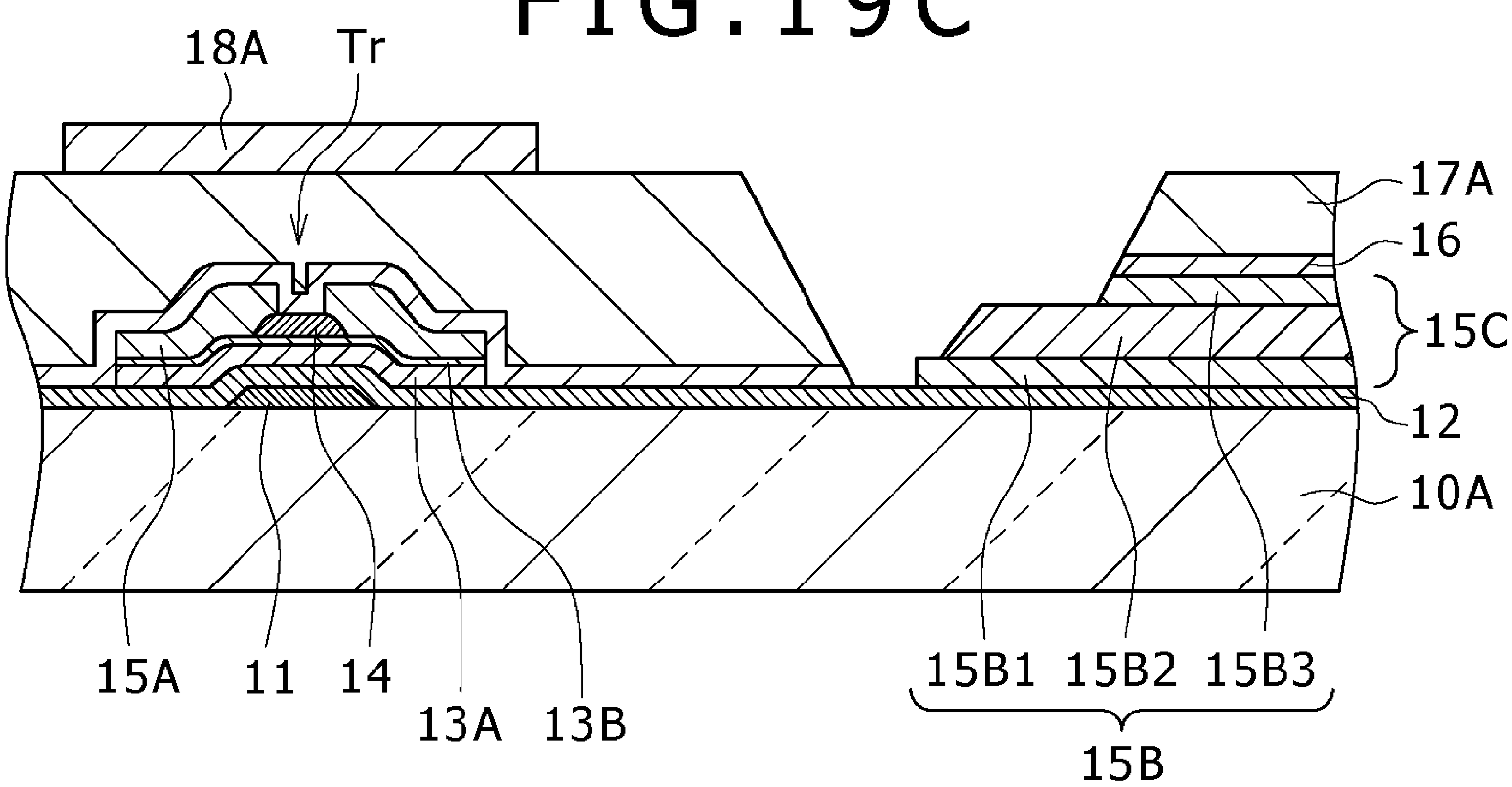


FIG.20A

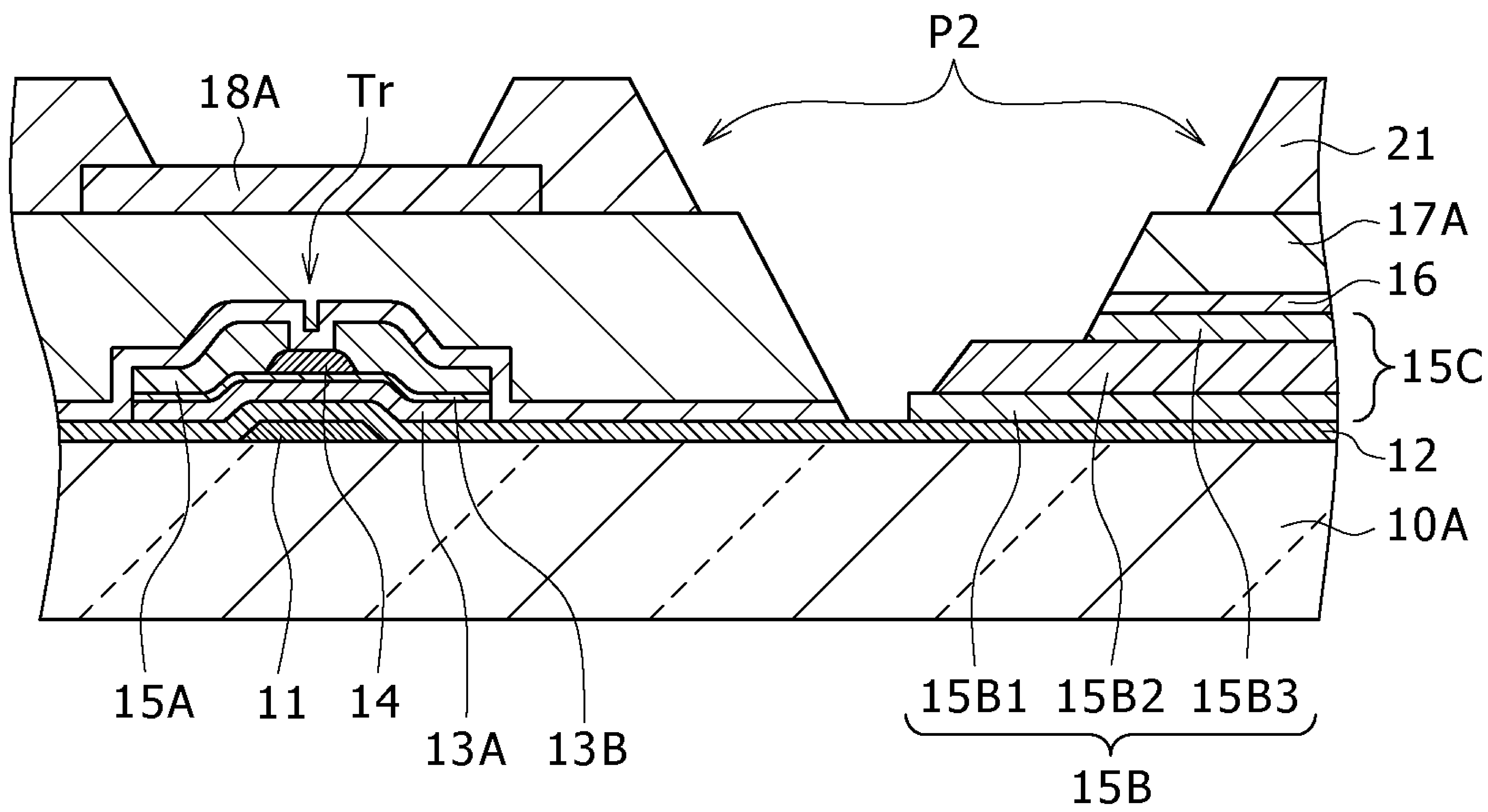


FIG.20B

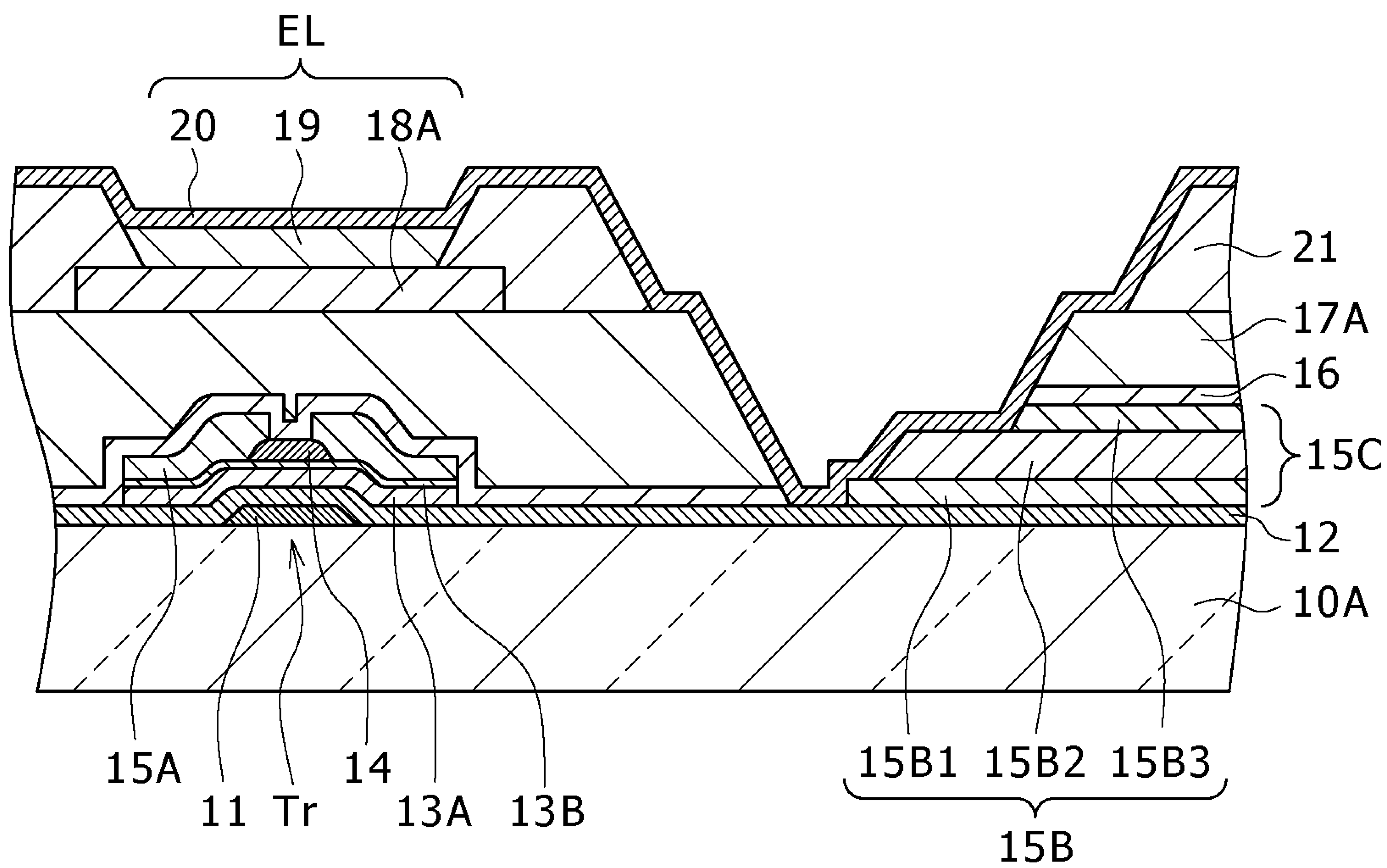


FIG.21

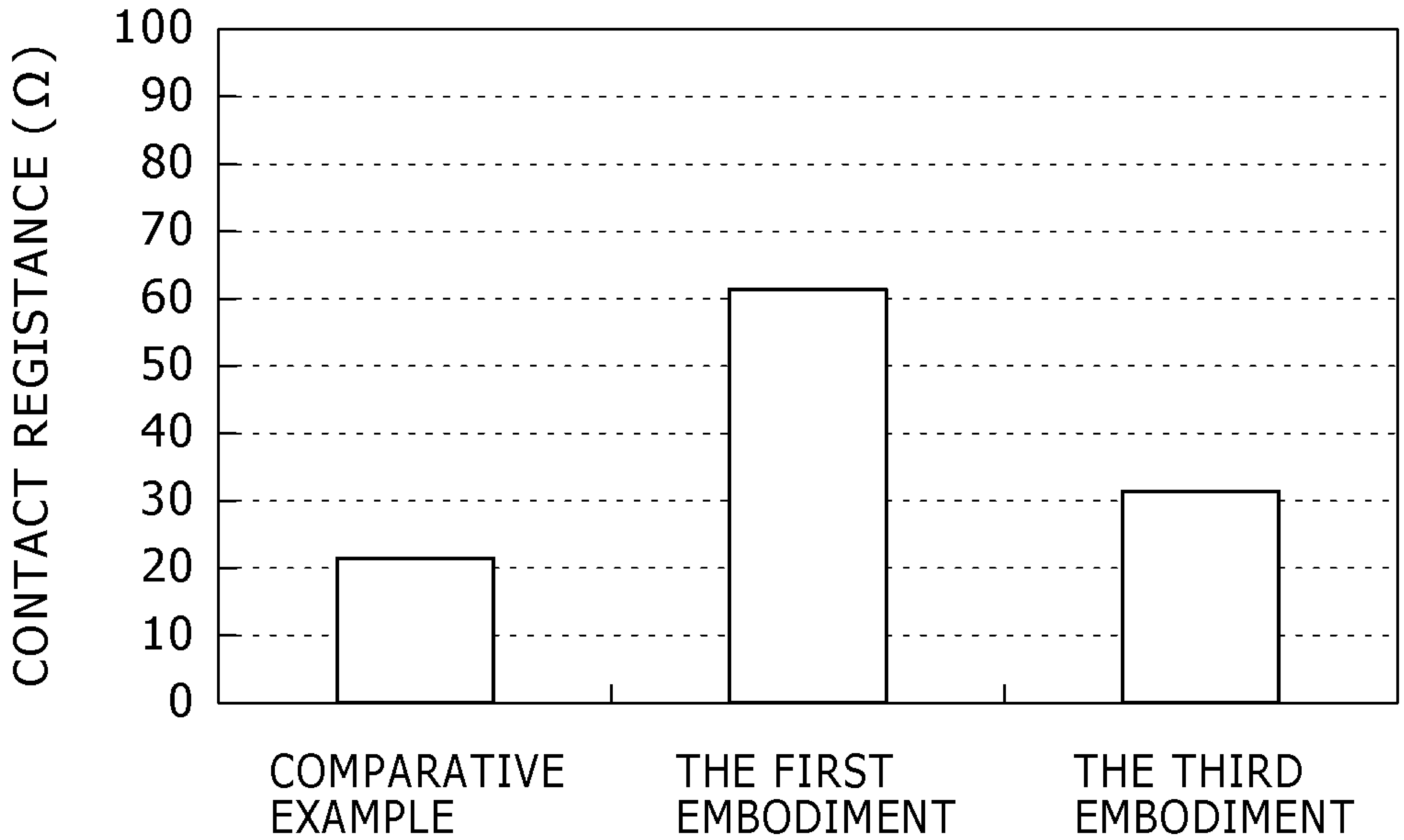

CONTACT REGISTANCE (Ω)
100
90
80
70
60
50
40
30
20
10
0
COMPARATIVE EXAMPLE
THE FIRST EMBODIMENT
THE THIRD EMBODIMENT

FIG.22

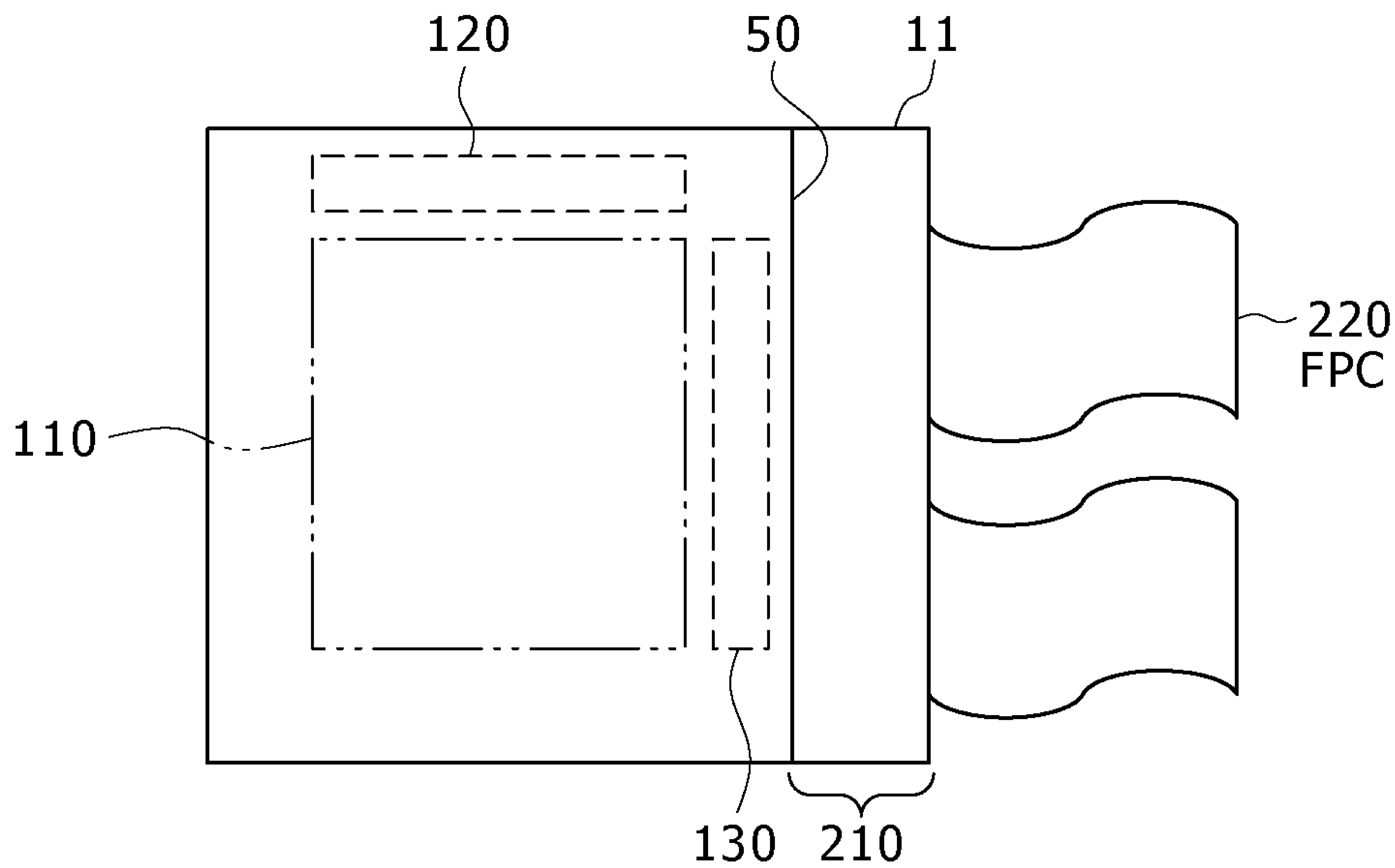


FIG.23

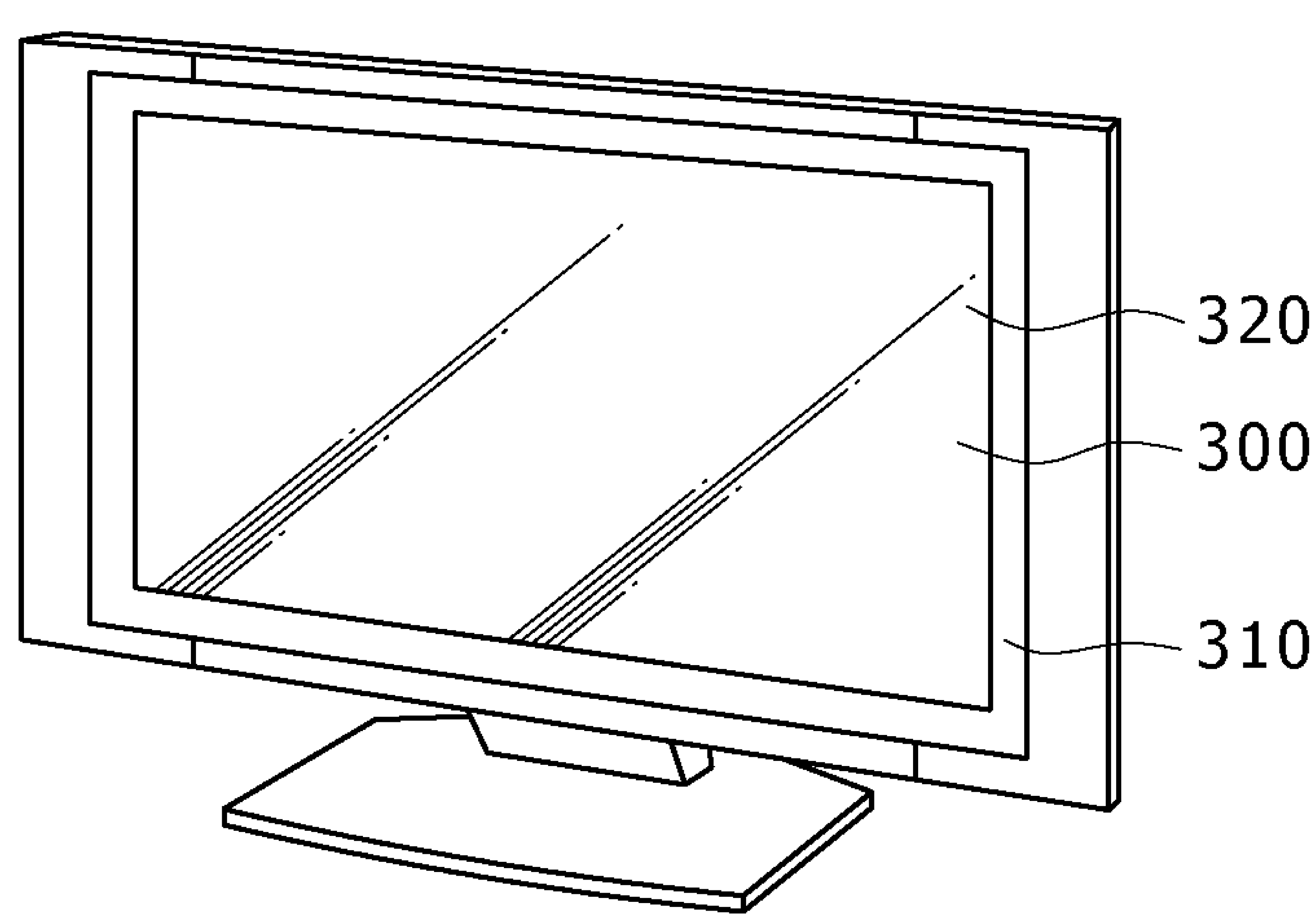


FIG.24A

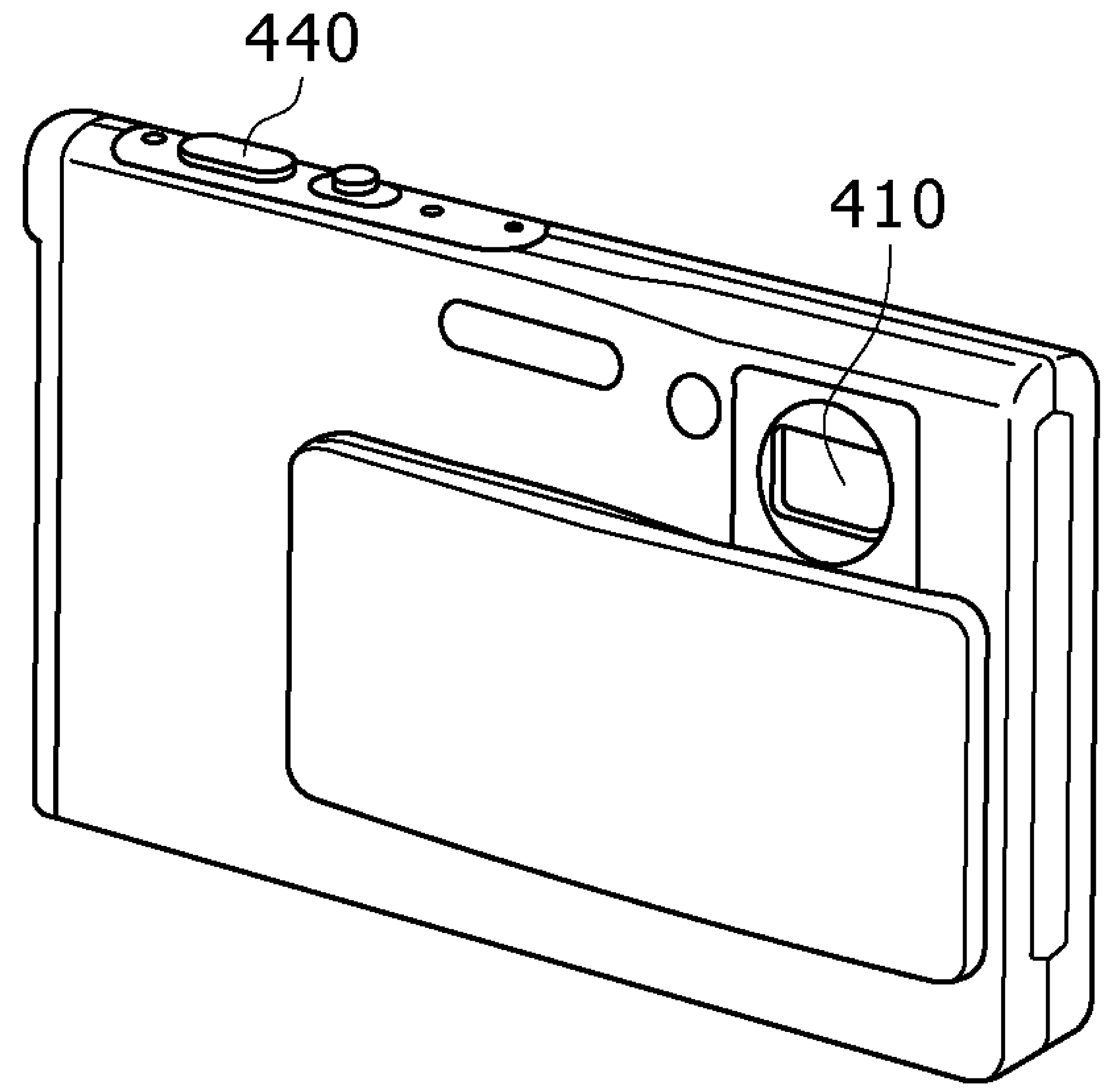


FIG.24B

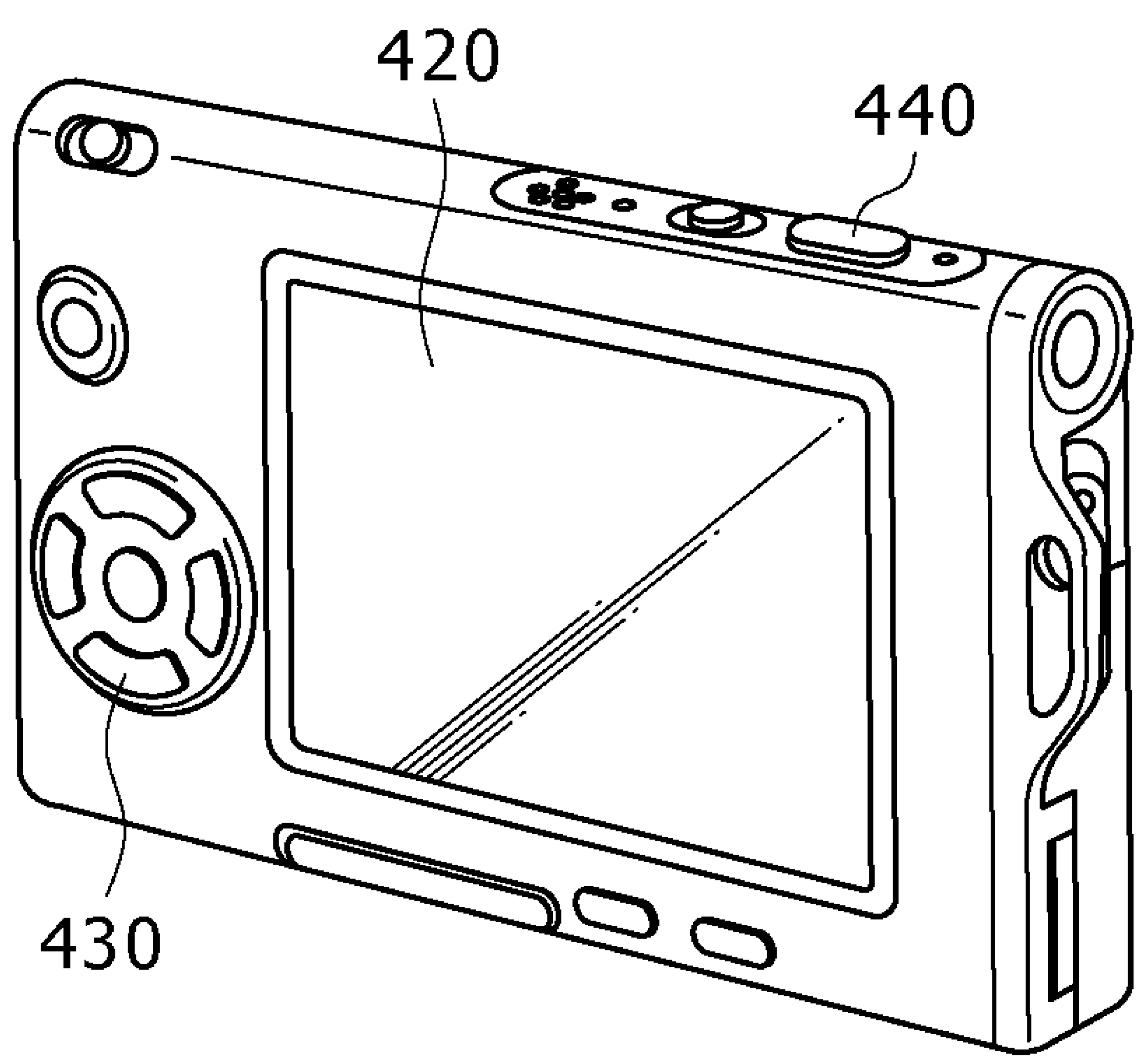


FIG.25

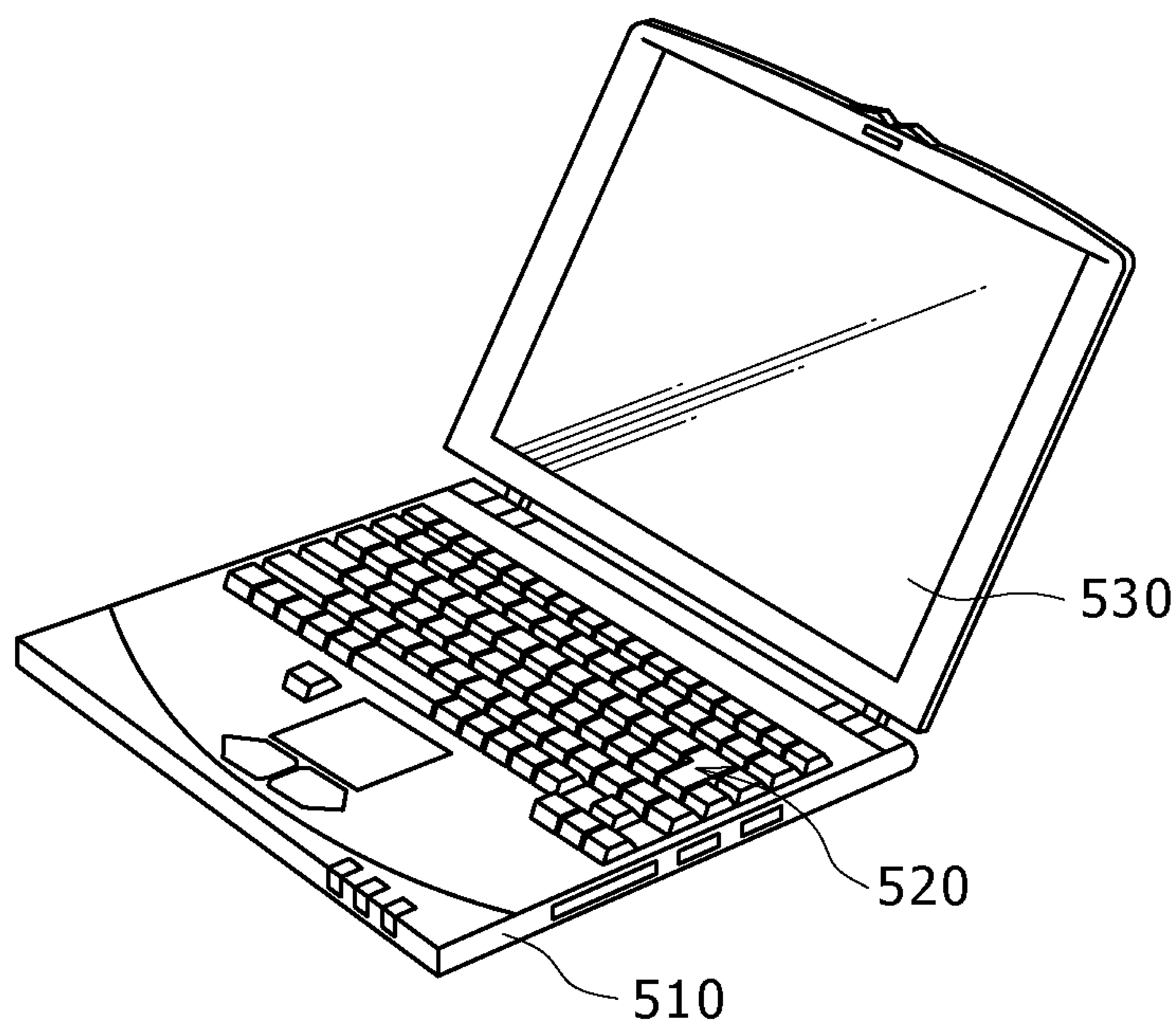
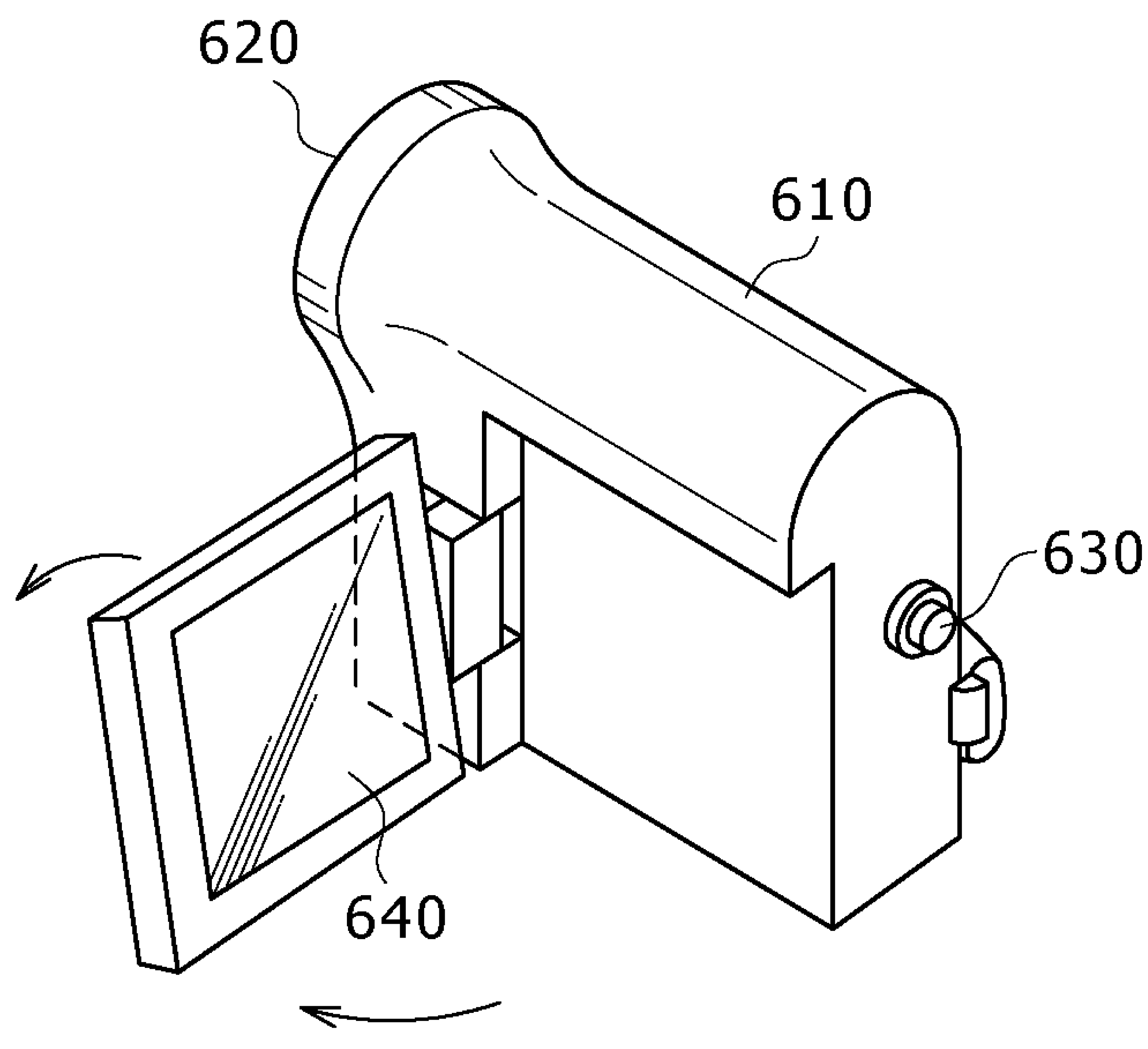


FIG.26



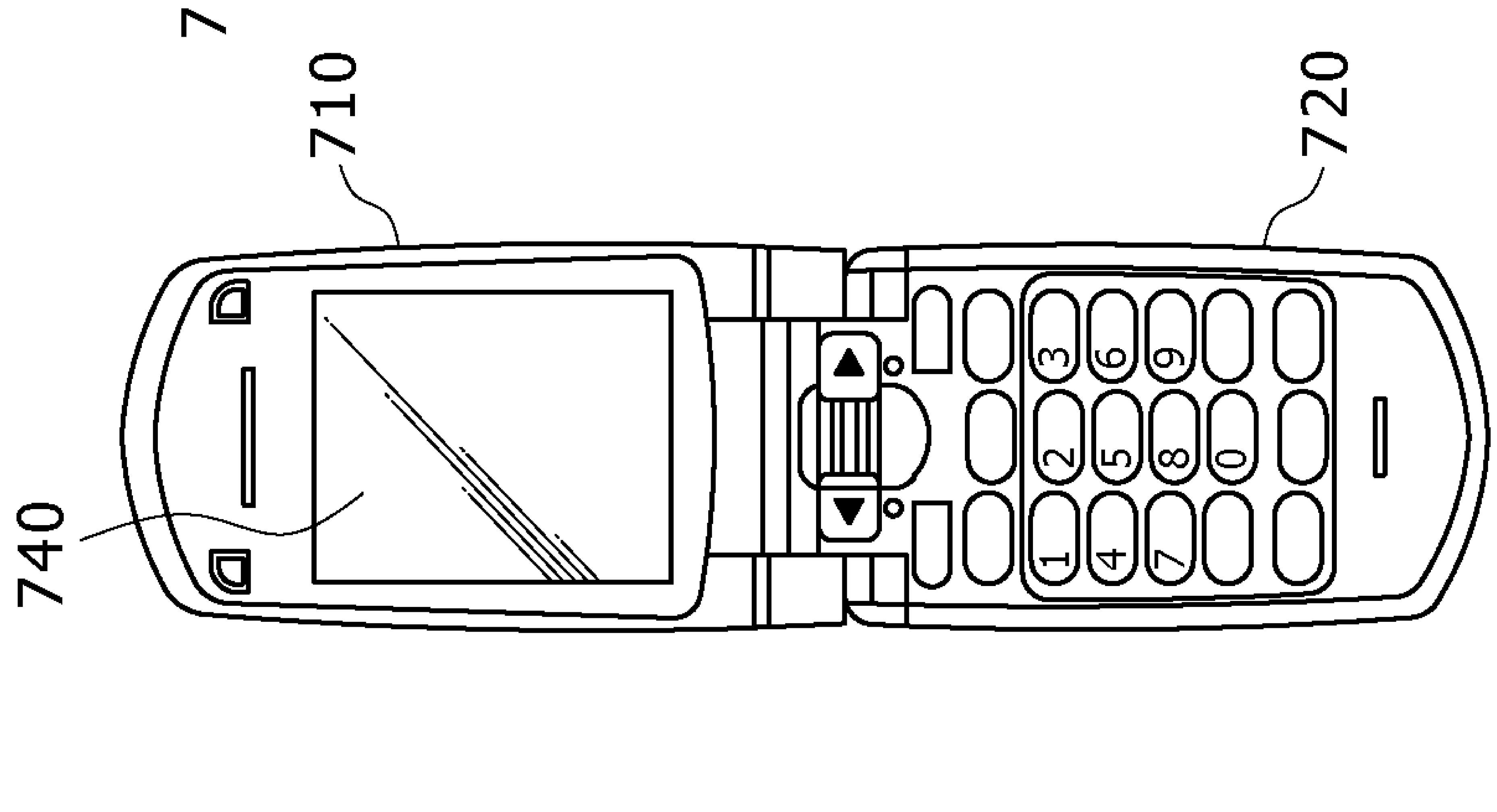


FIG.27A

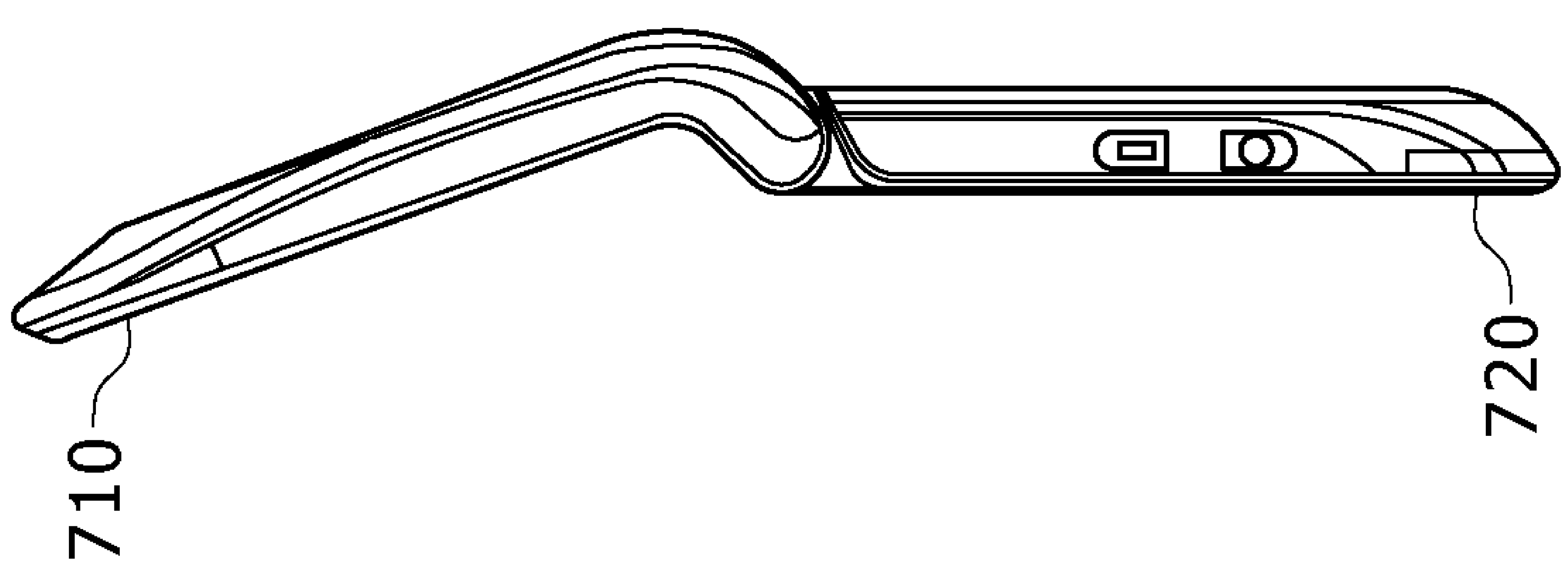


FIG.27B

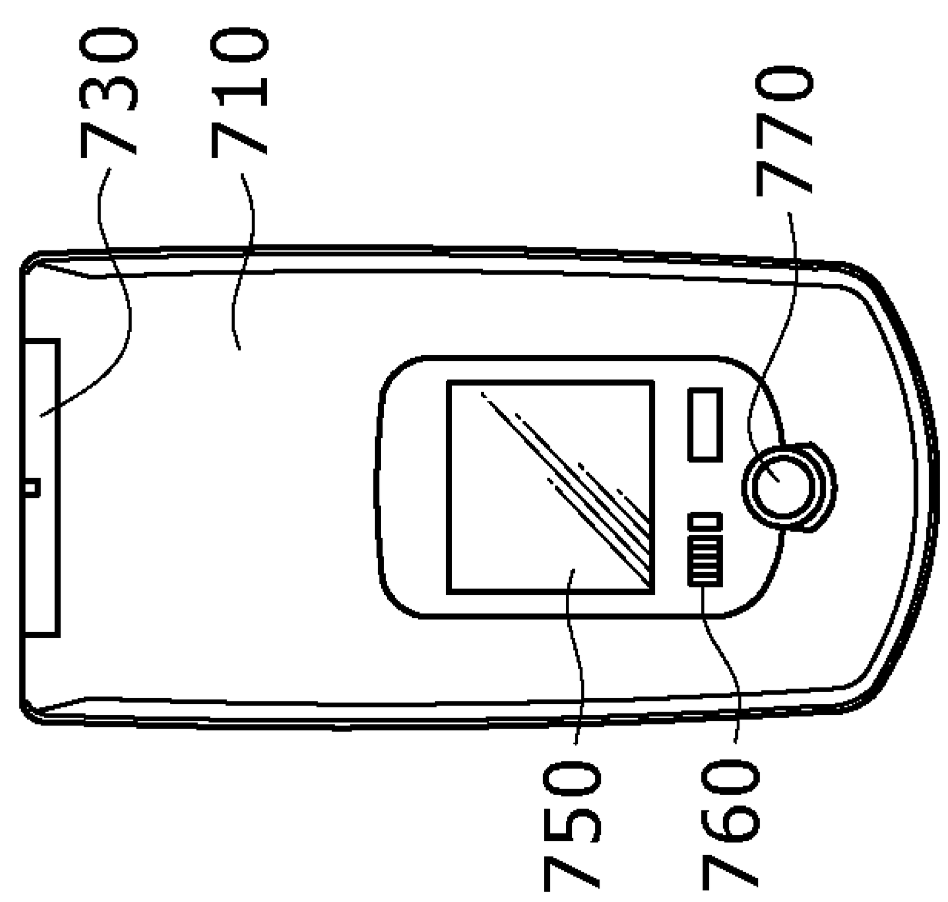


FIG.27C

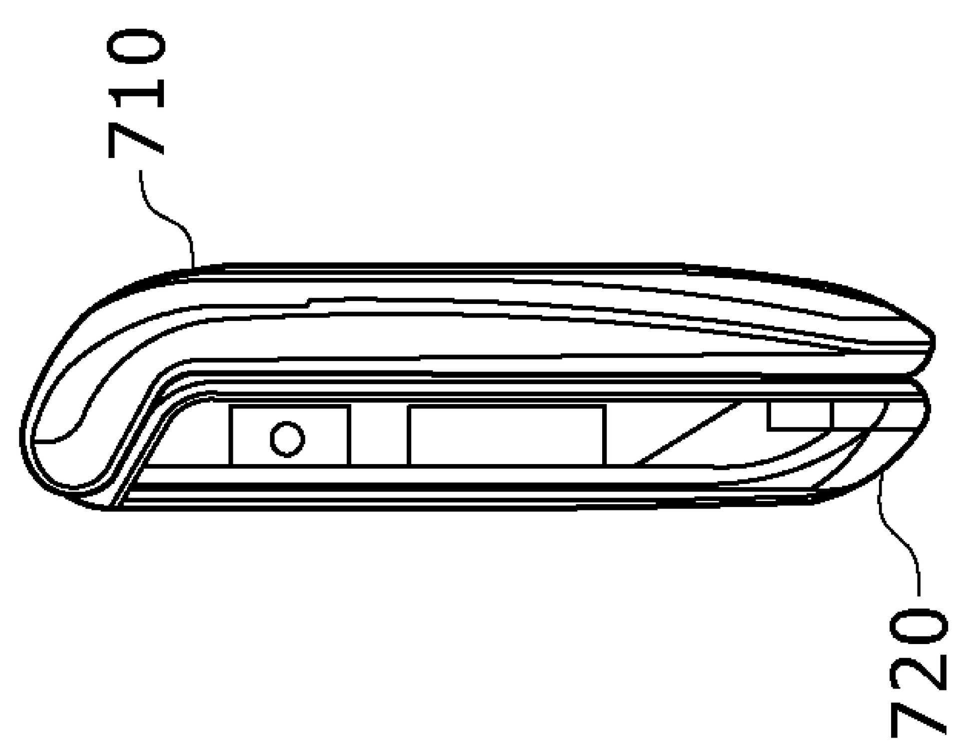


FIG.27D

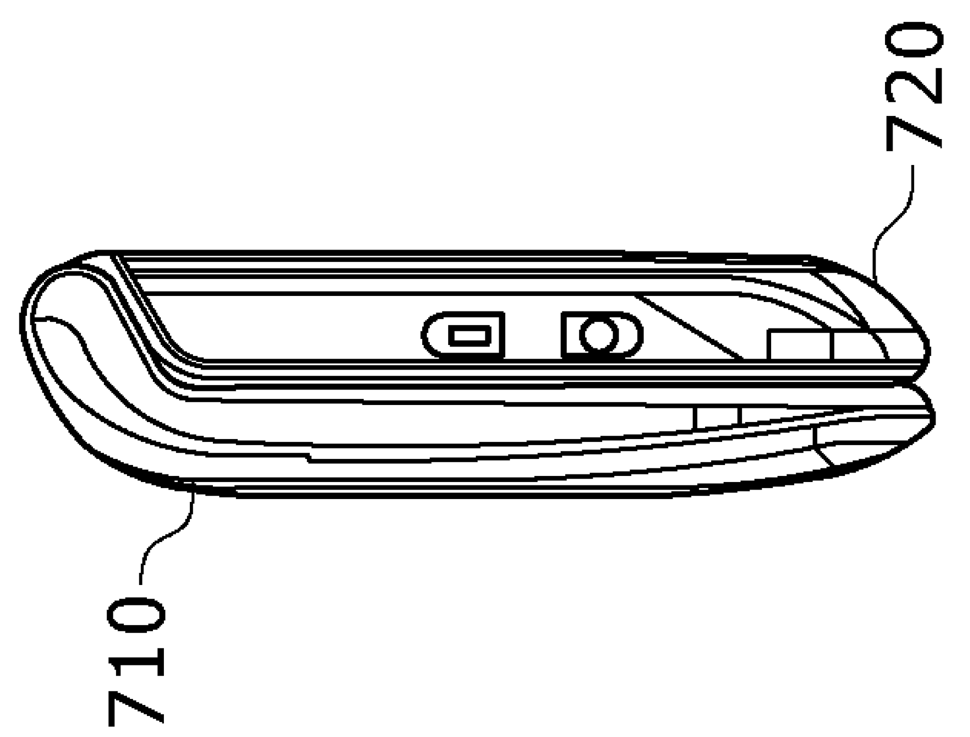


FIG.27E

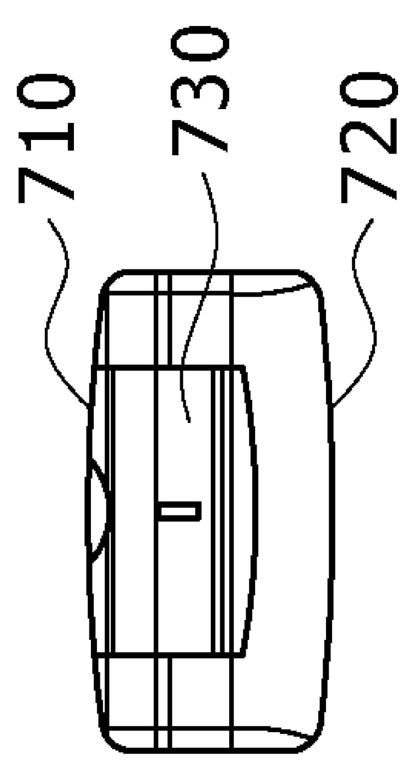


FIG.27F

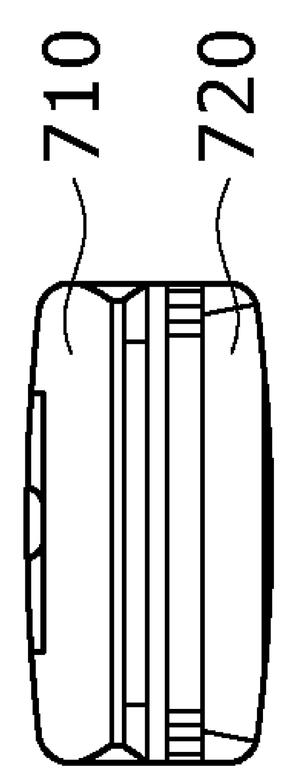


FIG.27G

DISPLAY DEVICE AND METHOD FOR PRODUCTION THEREOF

CROSS REFERENCES TO RELATED APPLICATIONS

The present invention contains subject matter related to Japanese Patent Application JP 2008-123004, and JP 2007-326595, both filed in the Japan Patent Office on May 9, 2008, and on Dec. 18, 2007, respectively, the entire contents of which being incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a display device of top emitting type and a method for production thereof.

2. Description of the Related Art

Among recent flat panel display devices attracting attention is the organic EL display device which displays images by means of organic EL (Electro Luminescence). The organic EL display device is a wide viewing angle and a low electric power consumption, the former being due to the fact that it utilizes emission from organic EL elements themselves. In addition, being highly responsive to high-definition high-speed video signals, the organic EL display device is expected to find practical use in the field of image technology. It is also attracting attention because it will find use as a flexible device if it is formed on a flexible plastic substrate that permits the organic emitting material to exhibit its inherent flexible properties.

The organic EL display device employs the driving system of either active matrix type or passive matrix type. The former, which employs TFT (Thin film Transistors) as driving elements, is superior to the latter in responsiveness and resolving power. Therefore, it is considered to be suitable particularly to the organic EL display device having the above-mentioned characteristics. The organic EL display device of active matrix type has organic EL elements (each including an organic emitting layer) and a driving panel on which are arranged driving elements (or TFT mentioned above) to drive the organic EL elements. To the driving panel is bonded (with an adhesive layer) a sealing panel so that they hold the organic elements between them. Each organic EL element has an organic emitting layer formed between a pair of electrodes.

The organic EL display device falls under bottom emission type and top emission type. The former permits each organic EL element to emit light through the driving panel mentioned above. The latter permits each organic EL elements to emit light through the sealing panel mentioned above. The latter is becoming the mainstream of development because of its larger aperture ratio.

Meanwhile, the organic EL display device of top emission type is constructed such that the electrodes on the sealing panel (through which light emerges) are common to every organic EL element. The electrodes are made of an optically transparent conductive material such as ITO (Indium Tin Oxide). Unfortunately, ITO has a higher resistivity than ordinary metallic materials by two to three orders of magnitude. The high resistivity causes the applied voltage to fluctuate over the electrode through which light emerges. This deteriorates the quality of display.

To tackle this problem, there has been proposed in Japanese Patent Laid-open No. 2002-318556 (hereinafter referred to as Patent Document 1) a technology to form an auxiliary wiring that connects with the electrode through which light emerges, the auxiliary wiring being formed at the same level as the electrode and from the same material as the electrode on the driving panel.

SUMMARY OF THE INVENTION

It would be possible to solve somewhat the above-mentioned problem with uneven voltage distribution within the electrode if an auxiliary wiring is formed from a material having a lower resistivity than the electrode through which light emerges and it is connected with the electrode through which light emerges.

However, the technology disclosed in Patent Document 1 mentioned above has the disadvantage that the auxiliary wiring made from the same material as the electrode is subject to surface oxidation if the electrode on the driving panel is made of aluminum or aluminum alloy. Surface oxidation results in an increased connecting resistance between the auxiliary wiring and the electrode through which light emerges and hence results in a large voltage drop across the oxidized part. This voltage drop in turn increases the power consumption of the device.

As mentioned above, the existing technology involves difficulties in avoiding increased power consumption without resorting to the auxiliary wiring and difficulties in improving the display quality by realizing even voltage distribution throughout the electrode through which light emerges.

The present embodiment was completed in view of the forgoing. It is desirable to provide a display device of top emitting type and a method for production thereof, the display device achieving low power consumption without resorting to auxiliary wiring and also having an improved display quality.

The present embodiment is directed to a display device having a plurality of driving elements and wiring parts electrically connected to the driving parts including a plurality of first electrodes which are formed in correspondence to each driving element on the driving elements and the wiring parts, a plurality of light-emitting parts which are each formed on the first electrodes, and a common second electrode which is formed from a material that transmits light from the light-emitting part and is formed on the light-emitting parts. The display device further includes auxiliary wiring parts with a lower resistance than the second electrodes, and contact parts which are formed in laminate structure from a plurality of conductive layers and which electrically connect the second electrodes and the auxiliary wirings with each other, with at least the lowermost conductive layer of the conductive layers of the contact parts being in direct contact with the second electrode.

The display device according to the present embodiment is constructed such that the second electrode and the auxiliary wiring are electrically connected to each other through the conductive contact part. The advantage of this structure is that even though the auxiliary wiring suffers surface oxidation, the contact resistance does not increase. Moreover, at least the lowermost conductive layer of the conductive layers of the contact part is in direct contact with the second electrode; therefore, even though the upper conductive layer suffers surface oxidation in the atmospheric air and electrical connection with the second electrode (through which light emerges) is impaired, good electrical connection is still maintained between the lower conductive layer and the electrode through which light emerges.

The present embodiment is directed also to a method for producing a display device including a step of forming on a substrate a plurality of driving elements and wiring parts such that these driving elements and wiring parts are electrically connected to each other, a step of forming a contact part having a laminate structure of a plurality of conductive layers, and a step of forming on the driving elements and the wiring parts a plurality of first electrodes corresponding respectively to the driving elements and also forming auxiliary wiring parts. The method further includes a step of forming light-emitting parts respectively on the first electrodes, and a step of forming on the light-emitting layers a common second electrode from a material that transmit light from each light-emitting part, with the auxiliary wiring being formed from a material having a lower resistance than the second electrode, and at least the lowermost conductive layer of the conductive layers of the contact parts being in direct contact with the second electrode.

The present embodiment is directly also to another method for producing a display device including a step of forming on a substrate a plurality of driving elements and wiring parts such that these driving elements and wiring parts are electrically connected to each other, a step of forming a contact part having a laminate structure of a plurality of conductive layers and integrally forming an auxiliary wiring part having the same laminate structure as the contact part, and a step of forming on the driving elements and the wiring parts a plurality of first electrodes corresponding respectively to the driving elements. The method further includes a step of forming light-emitting parts respectively on the first electrodes, and a step of forming on the light-emitting layers a common second electrode from a material that transmit light from each light-emitting part and electrically connecting between the second electrode and the auxiliary part through the contact part, with the auxiliary wiring being formed from a material having a lower resistance than the second electrode, and at least the lowermost conductive layer of the conductive layers of the contact parts being in direct contact with the second electrode.

The display device and the method for production thereof according to the present embodiment offer the following advantages. The second electrode and the auxiliary wiring are electrically connected to each other through the conductive contact part; therefore, even though the auxiliary wiring suffers surface oxidation, the contact resistance does not increase. Thus the display device ensures low power consumption and improved display device regardless of the structure of the auxiliary wiring.

The lowermost conductive layer of the contact part is electrically connected direct with the second electrode; even though the upper conductive layer suffers surface oxidation in the atmospheric air and electrical connection with the second electrode (through which light emerges) is impaired, good electrical connection is still maintained between the lower conductive layer and the electrode through which light emerges.

The wiring layer close to the driving elements is placed in the lower layer of the contact part, so that steps due to the planarized layer become smaller and the contact resistance decreases. Thus it is possible to improve yields without resorting to increasing the contact resistance.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram showing the structure of the display device pertaining to the first embodiment of the present invention;

FIG. **2** is an equivalent circuit diagram showing one example of the pixel driving circuit shown in FIG. **1**;

FIG. **3** is a plan view showing the structure of the display region shown in FIG. **1**;

FIG. **4** is a sectional view taken along the line IV-IV in FIG. **3**;

FIGS. **5**A and **5**B are sectional views showing the structure of the contact part in the display device shown in FIG. **3**;

FIG. **6** is a sectional view showing a portion of the major steps of the process for producing the display device shown in FIG. **3**;

FIGS. **7**A, **7**B and **7**C are sectional views showing steps that follow the steps shown in FIG. **6**;

FIGS. **8**A, **8**B and **8**C are sectional views showing steps that follow the steps shown in FIGS. **7**A, **7**B and **7**C;

FIGS. **9**A and **9**B are sectional views showing steps that follow the steps shown in FIGS. **8**A, **8**B and **8**C;

FIG. **10** is a sectional view showing the structure of the contact part in comparative example 1;

FIG. **11** is a sectional view showing the structure of the contact part of the display device pertaining to the second embodiment;

FIG. **12** is a sectional view showing the structure of the contact part in comparative example 2;

FIG. **13** is a diagram showing the results of evaluation of the contact resistance;

FIG. **14** is a plan view showing the structure of the display region of the display device pertaining to the third embodiment;

FIG. **15** is a sectional view taken along the line XV-XV in FIG. **14**;

FIGS. **16**A and **16**B are sectional views showing the structure of the contact part in the display device shown in FIG. **15**;

FIG. **17** is a sectional view showing a portion of the major steps of the process for producing the display device shown in FIG. **15**;

FIGS. **18**A, **18**B and **18**C are sectional views showing steps that follow the steps shown in FIG. **17**;

FIGS. **19**A, **19**B and **19**C are sectional views showing steps that follow the steps shown in FIGS. **18**A, **18**B and **18**C;

FIGS. **20**A and **20**B are sectional views showing steps that follow the steps shown in FIGS. **19**A, **19**B and **19**C;

FIG. **21** is a diagram showing the results of evaluation of the contact resistance;

FIG. **22** is a schematic plan view showing the structure of the module including the display device pertaining to the above-mentioned embodiment;

FIG. **23** is a perspective view showing an external appearance of application example 1 of the display device pertaining to the above-mentioned embodiment;

FIGS. **24**A and **24**B are perspective views each showing an external appearance of the front side and rear side of application example 2;

FIG. **25** is a perspective view showing an external appearance of application example 3;

FIG. **26** is a perspective view showing an external appearance of application example 4; and

FIGS. **27**A to **27**G are respectively a front view (in open state), a side view (in open state), a front view (in closed state), a left side view, a right side view, a top view, and a bottom view of application example 5.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiments of the present invention will be described below with reference to the accompanying drawings.

The First Embodiment

FIG. **1** is a diagram showing the structure of the display device (organic EL display device) pertaining to the first embodiment of the present invention. The organic EL display device **1** is one which is used as an organic color display device of very thin type. It is composed of a transparent substrate **10**A and a plurality of organic EL elements (EL) arranged thereon in a matrix pattern so as to form the display region **110**. It also has a signal driving circuit **120** and a scan line driving circuit **130** (both for image display), which are formed along the sides of the display region **110**.

The display region **110** has the pixel driving circuit **140** formed therein. FIG. **2** is a diagram showing an example of the pixel driving circuit **140**. The pixel driving circuit **140** is a driving circuit of active type, which is formed under the first electrode **18**A (mentioned later) and is composed of a driving transistor Tr**1**, a writing transistor Tr**2**, a capacitor Cs (placed between the two transistors), and an organic EL element (EL) which is placed between a first source line (Vcc) and a second source line (GND) and is serially connected to the driving transistor Tr**1**. The driving transistor Tr**1** and the writing transistor Tr**2** are ordinary thin film transistors (TFT), which may be either of inverse stagger type (so-called bottom gate type) or stagger type (so-called top gate type).

The pixel driving circuit **140** has a plurality of signal lines **120**A arranged in the column direction and a plurality of scan lines **130**A arranged in the row direction. The intersection of each signal line **120**A and each scan line **130**A corresponds to a subpixel which is any one of the organic EL elements (EL). Each signal line **120**A is connected to the signal line driving circuit **120**, so that an image signal is delivered to the source electrode of the writing transistor Tr**2** through the signal line **120**A. Each scan line **130**A is connected to the scan line driving circuit **130**, so that scan signals are sequentially delivered to the gate electrode of the writing transistor Tr**2** through the scan line **130**A.

FIG. **3** is a diagram showing the plane structure of the display region **110** of the organic EL display device **1**. FIG. **4** is a sectional view taken along the line IV-IV in FIG. **3**.

The organic EL display device **1** is composed of a pair of insulating transparent substrates **10**A and **10**B and multi-layered films held between them. Specifically, the multi-layered films include a gate electrode **11**, a gate insulating film **12**, a silicon film **13**A, a stopper insulating film **14**, an n^+-amorphous silicon film **13**B, and a wiring layer **15**A (source-drain electrodes), which are arranged upward. They constitute a thin film transistor Tr. On the thin film transistor Tr are placed an insulating protective film (passivation film) **16** and a planarized insulating film **17**A on top of the other. On the planarized insulating film **17**A is formed the organic EL element (EL) corresponding to the region in which the thin film transistor Tr is formed.

The transparent substrates **10**A and **10**B are formed from an insulating material such as glass or plastics.

The thin film transistor Tr is a driving element to drive each organic EL element (EL). The gate electrode **11** is formed from molybdenum (Mo) or the like, and the silicon film **13**A constitutes the channel region of the thin film transistor Tr and it is formed from amorphous silicon film or the like.

The wiring layer **15**A constitutes the source and drain electrodes of the thin film transistor Tr, and they function as the wiring such as signal line. The wiring layer **15**A is formed from a metal or alloy, such as titanium (Ti), titanium nitride (TiN), aluminum (Al), molybdenum (Mo), tungsten (W), chromium (Cr), gold (Au), platinum (Pt), copper (Cu), silver (Ag), ITO (indium titanium oxide), and IZO (indium zinc oxide).

The wiring layer **15**A may have a laminate structure, such as Mo/Al/Ti, Mo/AlSi alloy/Ti, Mo/(AlSiCu alloy/Ti, and Mo/(AlCe alloy)/Ti.

The protective insulating film **16** is intended to protect the thin film transistor Tr, and it is formed from at least one species of insulating materials such as SiO_2, SiN, and SiON. The planarized insulating film **17**A makes the layer structure plane so that the organic EL element (EL) is formed thereon. It is formed from an insulting material such as photosensitive polyimide resin, polybenzoxasole resin, novolak resin, polyhydroxystyrene resin, and acrylic resin.

Each organic EL element (EL) is composed of the first electrode **18**A, the organic light-emitting layer **19**, and the second electrode **20**, which are arranged downward to form a laminate structure. The first electrode **18**A and the organic light-emitting layer **19** are separated from each other by the electrode insulating film **21** on the planarized insulating film **17**A. As shown in FIG. **3**, the organic EL elements (EL), each taking on a rectangular shape, are arranged in a matrix pattern between the transparent substrates **10**A and **10**B. The second electrode **20** is common to all of the organic EL elements (EL), and it is uniformly formed between the transparent substrates **10**A and **10**B, as shown in FIG. **4**.

The first electrode **18**A functions not only as an anode or cathode to apply voltage to the organic light-emitting layer **19** but also as a reflecting electrode to lead upward the light from the organic light-emitting layer **19**. Therefore, the first electrode **18**A is formed from a metal or alloy having a high reflectivity, such as Al, AlNd, and AlCe. Unfortunately, these materials are liable to surface oxidation.

The organic light-emitting layer **19** is composed of a hole transporting layer, a light-emitting layer, and an electron transporting layer (all not shown), which are sequentially deposited and held between the first electrode **18**A and the second electrode **20**. The light-emitting layer **19** emits light, upon application of a prescribed voltage across the first electrode **18**A and the second electrode **20**, through recombination of carriers (holes and electrons) injected thereinto.

The second electrode **20** also functions as an anode or cathode to apply voltage to the organic light-emitting layer **19**. It is a transparent or translucent electrode that transmits light upward from the organic light-emitting layer **19**. It is made of a transparent material (such as ITO and IZO) or a translucent material (such as MgAg alloy, Cu, Ag, Mg, and Al).

As shown in FIGS. **3** and **4**, there is the auxiliary wiring **18**B formed at the same level as the first electrode **18**A in the region between the first electrodes **18**A. It is electrically connected to the second electrode **20** so than uneven voltage distribution is eliminated from the second electrode **20**, which is transparent and has a high resistance. Therefore, the auxiliary wiring **18**B is formed from a material having a lower resistance than the second electrode **20** or the same material as used for the first electrode **18**A.

The planarized insulating film **17**A and the electrode insulating film **21** each have the tapered part (which opens upward) in a part of the region where the auxiliary wiring **18**B is formed. Between the bottom of the tapered opening and the gate insulating film **12** is the conductive contact part **15**B. The second electrode **20** and the auxiliary wiring **18**B are electrically connected to each other above the contact part **15**B.

The contact part **15**B is formed from the same material as used for the wiring layer **15**A at the same level as the wiring layer **15**A. To be specific, the contact part **15**B is formed from titanium (Ti), titanium nitride (TiN), aluminum (Al), molybdenum (Mo), tungsten (W), chromium (Cr), gold (Au), platinum (Pt), copper (Cu), ITO (indium tin oxide), IZO (indium zinc oxide), silver (Ag), or alloy thereof. The constituent of the contact part **15**B may partly contain a conductive material that provides a good contact (preferably ohmic contact) with the second electrode **20**.

As shown in FIGS. **5**A and **5**B, which is an enlarged view, the contact part **15**B has a three-layered structure composed of the first to third conductive layers. The first conductive layer is the lowermost layer **15**B**1** of titanium (Ti), the second conductive layer is the intermediate layer **15**B**2** of aluminum (Al), and the third conductive layer is the uppermost layer **15**B**3** of molybdenum (Mo). The Ti layer **15**B**1** is wider than the Al layer **15**B**2** and the Mo layer **15**B**3**. This wider part W permits the Ti layer **15**B**1** to come into direct contact with the second electrode **20**. The organic EL display device **1** constructed in this manner ensures good electrical connection between the second electrode **20** and the auxiliary wiring **18**B through the Ti layer **15**B**1**, which is the lowermost layer of the contact part **15**B. This leads to low power consumption and improved display quality.

The lowermost layer (or Ti layer **15**B**1**) should preferably be formed from a material which exhibits high etching selectivity for the first electrode **18**A. Such a material protects the Ti layer **15**B**1** from etching to form the first electrode **18**A. The intermediate layer (or Al layer **15**B**2**) may be formed from AlSi alloy, AlSiCu alloy, or AlCe alloy. The uppermost layer (or Mo layer **15**B**3**) exists only in that portion of the contact part **15**B in which the auxiliary wiring **18**B exists, and it does not exist where the auxiliary wiring **18**B does not exist because it disappears at the time of etching for the auxiliary wiring **18**B in the manufacturing process described later.

The side of the opening of the electrode insulating film **21** expands gradually upward. The opening of the electrode insulating film **21** is wider than that of the planarized insulating film **17**A under which the contact part **15**B is formed. As shown in FIG. **4**, the second electrode **20** expands upward smoothly or stepwise. Expansion in this manner prevents wiring breakage or resistance increase that would otherwise occur when the second electrode **20** is formed. (A detailed description will be given later.) Incidentally, the electrode insulating film **21** is formed from an insulating material such as photosensitive polyimide resin.

In the organic EL element (EL) mentioned above, the second electrode **20** is uniformly coated with a protective film (not shown), and between the protective film and the transparent substrate **10**B is the sealing resin **17**B. The organic EL display device **1** constructed in this manner emits light upward through the second electrode **20** (close to the transparent substrate **10**B) from the organic light-emitting layer **19**. In other words, it is of top-emitting type.

The protective film (not shown) on the second electrode **20** is formed from an insulating material such as SiO_2, SiN, and SiON. The sealing resin **17**B planarizes the layer structure to be supported on the transparent substrate **10**B.

The thin film transistor Tr corresponds to the “driving element” in the present embodiment, the organic light-emitting layer **19** corresponds to the “light-emitting part” in the present embodiment, and the planarized insulating film **17**A and the electrode insulating film **21** correspond to the “insulating film” in the present embodiment.

The organic EL display device **1** is produced by the process which is described below with reference to FIGS. **6** to **9**B. FIGS. **6** to **9**B are sectional views illustrating part of the process for producing the organic EL display device **1**.

In the first step shown in FIG. **6**, the transparent substrate **10**A formed from the material mentioned above undergoes sputtering, CVD (chemical vapor deposition), or photolithography to sequentially deposit thereon the gate electrode **11** of the material mentioned above (100 nm thick), the gate insulating film **12** (400 nm thick), the silicon film **13**A (30 nm thick), the stopper insulating film (300 nm thick), the n^+-amorphous silicon film **13**B (100 nm thick), and the wiring layer **15**A (600 nm thick). In this way there are obtained thin film transistors Tr arranged in a matrix pattern.

When the wiring layer **15**A is formed by, say, sputtering, the contact part **15**B of the same structure as the wiring layer **15**A is also formed simultaneously from the same material as used for the wiring layer **15**A. The contact part **15**B is formed on the gate insulating film **12** or at the same level as the wiring layer **15**A in the region between the first electrodes **18**A as shown in FIG. **4**.

The process of forming the contact part **15**B consists of the following three steps shown in FIGS. **7**A, **7**B and **7**C. As shown in FIG. **7**A, the gate insulating film **12** is coated sequentially with the Ti layer **15**B**1** (50 nm thick), the Al layer **15**B**2** (500 nm thick), and the Mo layer **15**B**3** (50 nm thick) by sputtering. As shown in FIG. **7**B, the top layer is coated with the photoresist film (PH), which is subsequently used as a mask for wet etching with a mixture of phosphoric acid, nitric acid, and acetic acid. This etching removes the unmasked part of the Mo layer **15**B**3** and also selectively removes the unmasked part of the Al layer **15**B**2**. As shown in FIG. **7**C, the Ti layer **15**B**1** is selectively removed by dry etching with chlorine gas in such a way that its surface is partly exposed to form the wider part W as shown in FIG. **3**.

The photoresist film (PH) is finally removed. In this way the contact part **15**B is formed at the same level as the wiring layer **15**A.

The process according to this embodiment eliminates defective patterning due to etching because it forms the contact part **15**B by photolithography, wet etching (with a mixture of acids) on the Al layer **15**B**2**, and dry etching (with chlorine gas) on the Ti layer **15**B**1**.

In other words, the process according to this embodiment offers the advantage of reducing defective patterning due to dry etching. This advantage arises from the fact that dry etching gives a small difference between the line width of the photoresist pattern and the line width of the etched pattern. Since the Mo layer **15**B**3** and the Al layer **15**B**2**, which are the uppermost and intermediate layers, undergo wet etching, whereas the Ti layer **15**B**1**, which is the lowermost layer, undergoes dry etching, the Ti layer is wider than the Al layer as a matter of course. The Al layer **15**B**2** is naturally oxidized in the atmospheric air and hence becomes poor in electrical connection with the second electrode **20** through which light emerges. However, good electrical connection is maintained between the Ti layer **15**B**1**, which is the lowermost layer, and the second electrode **20**.

Incidentally, in the case where wet etching is performed on a Ti/Al/Ti laminate structure (see comparative example 2 given later), the edge of the upper Ti layer becomes unstable and breaks to give rise to foreign matter that causes defective patterning, if the Al layer has a faster etching rate than the upper Ti layer. This is because the etching rate greatly differs between Ti and Al.

The foregoing process to form the thin film transistor Tr and the contact part **15**B is followed by the next process consisting of three steps shown in FIGS. **8**A to **8**C.

The step shown in FIG. **8**A is intended to evenly form the protective insulating film **16** (from the same material as mentioned above) by CVD on the thin film transistor Tr and the contact part **15**B. Then, the protective insulating film **16** is evenly coated with the planarized insulating film **17**A (of the same material as mentioned above) by spin coating or slit coating. The region corresponding to the contact part **15**B undergoes photolithography for exposure and development to make an opening. After baking, there is obtained an opening with tapered sides indicated by P1 in FIG. 8A. The planarized insulating film is formed from a photosensitive resin which gives a gentle slope. The opening with a gentle slope may also be formed by using a multi-tone mask such as half-tone mask or gray-tone mask, or by performing exposure several times through several masks differing in the size of the opening. The slope of the taper may be properly established according to the thickness and forming method of the second electrode **20**.

In the next step shown in FIG. **8**B after the opening has been formed in the planarized insulating film **17**A, the planarized film **17**A and the contact part **15**B are evenly coated with the metal layer **18** (about 300 nm thick) by sputtering. This metal layer **18** is formed from the same material as used for the first electrode **18**A and the auxiliary wiring **18**B mentioned above.

In the next step shown in FIG. **8**C after the metal layer **18** has been formed, the metal layer **18** undergoes selective etching by photolithography, so that the first electrode **18**A and the auxiliary wiring **18**B shown in FIGS. **3** and **4** are formed. The first electrode **18**A is formed at a position corresponding to the thin film transistor Tr, and the auxiliary wiring **18**B is formed in the region between the first electrodes **18**A. Patterning is performed in such a way that a portion of the auxiliary wiring **18**B is electrically connected to the contact part **15**B. It is not always necessary that the contact part **15**B be formed from a material having a high etching selectivity for the metal layer **18**; it may be formed from any material having a high selectivity for the conductive material. There is no possibility that the conductive material of the contact part **15**B is etched altogether. An adequate etching method may be selected.

In the next step shown in FIG. **9**A after the first electrode **18**A and the auxiliary wiring **18**B have been formed, the planarized insulating film **17**A, the first electrode **18**A, and the auxiliary wiring **18**B are evenly coated with the electrode insulating film **21** of the same material as mentioned above by spin coating or slit coating. The coating is subsequently patterned into a desired shape by photolithography so that the first electrodes **18**A and the organic light-emitting layers **19** are separated from each other. At this time, the region corresponding to the contact part **15**B is selectively removed by photolithography so that the tapered opening indicated by P**2** in FIG. **9**A is formed. The tapered opening is formed in such a way that its slope is as gentle as possible. This object is achieved by using a multi-tone mask such as half-tone mask and gray-tone mask, or by repeating exposure several times through several masks differing in the size of the opening. The opening in the electrode insulating film **21** should have a tapered shape that opens upward.

In the next step shown in FIG. **9**B after the electrode insulating film **21** has been formed, the first electrode **18**A is coated with the organic light-emitting layer **19** by vacuum deposition. Then, the organic light-emitting layer **19**, the electrode insulating film **21**, the planarized insulating film **17**A, the contact part **15**B, and the auxiliary wiring **18**B are coated by vacuum deposition with the second electrode **20** (about 10 nm thick) of the same material as mentioned above.

Finally, the second electrode **20** is evenly coated by CVD with a protective film (not shown) of the same material as mentioned above. On the protective film (not shown) is cast the sealing resin **17**B and the entire assembly is held between the transparent substrates **10**B and **10**A. In this way there is obtained the organic EL display device **1** (shown in FIGS. **3** and **4**) as intended by the embodiment.

The organic EL display device **1** operates in the following manner. Upon application of voltage to the first electrode **18**A through the wiring layer **15**A and the thin film transistor Tr, the organic light-emitting layer **19** emits light with a luminance proportional to the potential across the first electrode **18**A and the second electrode **20**. The light from the organic light-emitting layer **19** is reflected by the first electrode **18**A and passes through the second electrode **20**. Thus the emitted light emerges upward (in FIG. **4**) through the transparent substrate **10**B. Each organic EL element (EL) in each pixel emits light in response to pixel signals, and the organic EL display device **1** displays a desired image.

The advantage of the organic EL display device **1** is as follows. The second electrode **20** and the auxiliary wiring **18**B are electrically connected to each other through the conductive contact part **15**B which resists surface oxidation and provides good connection (preferably ohmic connection) with the second electrode **20**. Therefore, even though surface oxidation occurs in the auxiliary wiring **18**B of the same material as the first electrode **18**A, connection resistance does not increase between the second electrode **20** and the auxiliary wiring **18**B. To be specific, the passage (P) of electrical connection is the second electrode **20**→the wider part W of the lowermost Ti layer **15**B**1**→the intermediate Al layer **15**B**2**→the uppermost Mo layer **15**B**3**→the auxiliary wiring **18**B, as shown in FIG. **4**.

Incidentally, the existing EL display device **101** (comparative example 1) shown in FIG. **10** is that the auxiliary wiring **118**B is formed from the same material as the first electrode **18**A at the same level as the first electrode **18**A and is directly connected to the second electrode **120**. The disadvantage of this structure is that when the auxiliary wiring **118**B suffers surface oxidation, the connecting resistance increases between the second electrode **120** and the auxiliary wiring **118**B.

By contrast, the organic EL display device **1** of this embodiment is constructed such that the auxiliary wiring **18**B is formed at the same level as the first electrode **18**A and only a portion of the auxiliary wiring **18**B in the region between the first electrode **18**A and the auxiliary wiring **18** is connected to the contact part **15**B at the same level as the wiring layer **15**A. Therefore, the layout is not restricted by the thin film transistor Tr and the wiring layer **15**A when the contact part **15**B is formed.

As mentioned above, this embodiment is characterized in that the second electrode **20** and the auxiliary wiring **18**B are electrically connected to each other through the conductive contact part **15**B and only a portion of the auxiliary wiring **18**B is connected to the contact part **15**B. The advantage of this structure is that even though the auxiliary wiring **18**B suffers surface oxidation, there is no possibility of the contact resistance increasing and the layout is not restricted when the contact part **15**B is formed. This ensures free layout and low power consumption, and the resulting organic EL display device **1** has an improved display quality.

The fact that the layout is not restricted when the contact part **15**B is formed leads to freedom from defects due to shorts that might occur in the wiring layer **15** because of unnatural layout.

The fact that the contact part **15**B is formed from the same material as the wiring layer **15**A at the same level as the wiring layer **15**A is a reason why the manufacturing steps do not increase (and hence the production cost remains low) even though the contact part **15**B is formed. In other words, the wiring layer **15**A and the contact part **15**B are formed in the same step and hence this simplifies the manufacturing process.

Moreover, the fact that the contact part **15**B is formed from a material which has a higher etching ratio relative to the first electrode **18**A eliminates the possibility of the contact part **15**B being etched when the first electrode **18**A and the auxiliary wiring **18**B are formed by etching the metal layer **18**. This ensures the formation of the contact part **15**B.

Moreover, the fact that the planarized insulating film **17**A and the electrode insulating film **21** are formed such that their sides are tapered (expanding upward) prevents the second electrode **20** from suffering breakage and increasing in resistance in the sides of the opening. This contributes to good production yields.

Moreover, this embodiment is the layered structure of the contact part **15**B. That is, the contact part **15**B is composed of the lowermost Ti layer **15**B**1** (the first conducting layer), the intermediate Al layer **15**B**2** (the second conducting layer), and the uppermost Mo layer **15**B**3**. And, the Ti layer **15**B**1** has a wider part W which is wider than the Al layer **15**B**2** and the Mo layer **15**B**3**, so that the second electrode **20** comes into direct contact with the Ti layer **15**B**1**. The advantage of this structure is that even though the intermediate Al layer **15**B**2** suffers natural oxidation in the atmospheric air and electrical contact with the second electrode **20** (through which light is extracted) becomes poor, good electrical contact is still maintained between the lowermost Ti layer **15**B**1** and the electrode through which light emerges.

Moreover, the fact that the contact part **15**B is formed by wet-etching the Mo layer **15**B**3** and the Al layer **15**B**2** with mixed acids as an etchant and then dry-etching the Ti layer **15**B**1** with chlorine gas reduces defective patterning due to dry etching while utilizing the advantage of dry etching that there is a small difference between the line width of photoresist pattern and the line width of etched pattern. A detailed description about this will be given later.

The Second Embodiment

The following deals with the display device pertaining to the second embodiment of the present invention. The constituents common to the first and second embodiments are given the same symbols and their explanation is not repeated.

FIG. **11** is a sectional view showing the structure of the contact part **25**B of the display device (organic EL display device) pertaining to this embodiment. The contact part **25**B has on the transparent substrate **11**A the low-resistance wiring layer **26** as the lowermost layer which is identical with the source signal line or gate wiring connected to the thin film transistor Tr. The low-resistance wiring layer **26** is 500 nm thick and has the layer identical with the gate electrode **11**, the gate insulating layer **12**, the silicon film **13**A, the stopper insulating film **14**, and the n^+-amorphous silicon film **13**B which are sequentially formed thereon upward. The low-resistance wiring layer **26** prevents the gate wiring, the source signal line, and the current supply line from increasing in resistance in proportion to their length as the display screen becomes larger and improves in definition. Incidentally, the low-resistance wiring layer **26** is not necessary in the thin film transistor Tr, and hence it is not included in the first embodiment shown in FIGS. **5**A and **5**B. The second embodiment is identical in structure with the first one except for the part relating to the thin film transistor Tr and the protective insulating film **16**.

This embodiment is that the low-resistance wiring layer **26** exists under the contact part **25**B. This structure reduces the distance between the first electrode **18**A and the second electrode **20**, with the result that steps due to the planarized film become smaller and the contact resistance decreases more than that in the first embodiment and that resistance increase due to breakage is less liable to occur. Other effects of the second embodiment are identical with those of the first embodiment.

The contact parts **15**B and **25**B of the first and second embodiments differ from in contact resistance from those in comparative example 2 shown in FIG. **12**, which is explained in the following.

Comparative Example 2

FIG. **12** is a sectional view showing the structure of the contact part **115**B in comparative example 2. The contact part **115**B corresponds to the contact part **15**B shown in FIGS. **5**A and **5**B. The wiring layer **115**A and the contact part **115**B each have a three-layer structure composed of the Ti layer **115**B**3** (50 nm thick), the Al layer **115**B**2** (500 nm thick), the Ti layer **115**B**1** (50 nm thick). The second electrode **120** is placed on the protective insulating film **116** and the planarized insulating film **117**A so that it is electrically connected to the upper Ti layer **115**B**3**. Except for this structure, comparative example 2 is identical with the first and second embodiments mentioned above.

Incidentally, the structure of comparative example 2 is included in the specification attached to the application (Japanese Patent Application No. 2006-168906) filed on Jun. 19, 2006 by the present applicant. The invention of the previous application is intended to achieve good electrical connection between the auxiliary wiring **118**B and the second electrode **120** (through which light emerges) by way of the contact part **115**B of layered structure, with the uppermost layer being formed from Ti. Such good electrical connection is expected to raise the reflectivity of the electrode close to the driving panel and to lower the resistance of the auxiliary wiring.

Incidentally, in the case where the contact part **115**B for electrical connection between the auxiliary wiring **118**B and the second electrode **120** (through which light is extracted) is a layered film of Ti and Al as in comparative example 2, etching for the layered film of Ti and Al is usually accomplished by reactive etching with chlorine gas or boron trichloride gas. The reactive etching offers an advantage of giving a small difference between the line with of the photoresist pattern and the line width of the etched pattern. However, it also has a disadvantage of causing defective patterning due to foreign matter which occurs when Al undergoes etching. This disadvantage leads to low yields if the Al film is made thicker to reduce the resistance of the source signal liens and current supply lines for a larger panel and higher definition.

In addition, the contact part **115**B should desirably be formed at the same level as the source-drain wiring of the thin film transistor Tr in order to simplify the manufacturing process. However, in the case of organic EL display device of top emission type, it is common practice to place a planarized layer of polyimide or acrylic resin between the source-drain layer and the pixel electrode layer constituting pixel electrodes. This planarized layer is about 2 μm thick and is formed by spin coating as in the case of photoresist. In this case, the electrode through which light emerges is connected to the contact part **115**B through the contact hole formed in the planarized layer. However, connection in this manner has to get over steps of the planarized layer and this poses a problem with increase in contact resistance.

The contact resistance was evaluated in the following manner. In the case of comparative example 2, the contact part **115**B is formed such that its end does not expose itself. In the case of the first and second embodiments, the contact parts **15**B and **25**B are formed such that the end of the Ti layer exposes itself. In all the cases, the second electrode has a contact width of 20 μm and a contact length of 100 μm. The resistance R is calculated from the voltage V which is produced by the current I of 100 μA, and the contact resistance between the first and second electrodes is measured. The results are shown in FIG. **13**.

It is noted from FIG. **13** that the structure (according to the first embodiment) shown in FIGS. **5**A and **5**B has a slightly high contact resistance, whereas the structure (according to the second embodiment) shown in FIG. **11** and the structure according to comparative example 2 have almost the same contact resistance. This result suggests that the contact resistance does not substantially increase even though the above-mentioned technology is used to maintain yields in the process of forming the wiring. Incidentally, the structure (according to the first embodiment) shown in FIGS. **5**A and **5**B produces resistance due to connection between the contact part **15**B and the auxiliary wiring **18**B, but the increase in resistance is insignificant because the resistance is ohmic contact resistance.

The Third Embodiment

FIG. **14** is a diagram showing the plane structure of the display region **110** of the organic EL display device **1** according to the third embodiment of the present invention. FIG. **15** is a sectional view taken along the line XV-XV in FIG. **14**. This organic EL display device **1** is identical in structure with the one according to the first embodiment mentioned above, except that the auxiliary wiring **15**C has the same layered structure as the contact part **15**B and is formed integrally with the contact part **15**B. Thus, the corresponding constituents are given the same reference characters.

This embodiment is identical with the first embodiment in that the same structure is adopted for the transparent substrates **10**A and **10**B, the thin film transistor Tr, the wiring layer **15**A, the contact part **15**B, the protective insulating film **16**, the planarized insulating film **17**A, the electrode insulating film **21**, the sealing resin **17**B, and the organic EL element (EL).

The auxiliary wiring **15**C is formed in the region between the first electrodes **18**A at the same level as the wiring layer **15**A. Like the auxiliary wiring **18**B in the first embodiment, the auxiliary wiring **15**C is intended to eliminate uneven voltage distribution in the transparent second electrode **20** having a high resistance. Therefore, the auxiliary wiring **15**C is so constructed as to have a lower resistance than the second electrode **20** (or it is made of a material having a low resistivity). To be specific, the auxiliary wiring **15**C has the same layered structure as the contact part **15**B, as shown in FIGS. **16**A and **16**B, and it is formed integrally with the contact part **15**B. Owing to this structure, the organic EL display device **1** has a much smaller contact resistance between the auxiliary wiring **15**C and the contact part **15**B.

The planarized insulating film **17**A and the electrode insulating film **21** have a tapered opening (expanding upward) in a portion of the region in which the auxiliary wiring **15**C is formed. (See FIG. **15**.) Between the bottom of the opening and the gate insulating film **12** is formed the conductive contact part **15**B at the same level as the wiring layer **15**A. It is on this contact part **15**B that the second electrode **20** and the auxiliary wiring **15**C are electrically connected to each other.

The organic EL display device **1** may be produced in the following manner.

First, a plurality of thin film transistors Tr are formed on the transparent substrate **10**A, as shown in FIG. **17**, in the same way as in the first embodiment.

The wiring layer **15**A and the contact part **15**B are formed simultaneously from the same material. The contact part **15**B is formed on the gate insulating film **12**, that is, at the same level as the wiring layer **15**A, and in the region between the first electrodes **18**A, as shown in FIG. **15**. At this time, the auxiliary wiring **15**C and the contact part **15**B are formed integrally with each other.

First, the gate insulating film **12** is coated by sputtering sequentially with the Ti layer **15**B**1** (50 nm thick), the Al layer **15**B**2** (500 nm thick), and the Mo layer **15**B**3** (50 nm thick), as shown in FIG. **18**A. Next, wet etching with a mixture of phosphoric acid, acetic acid, and nitric acid is performed through the photoresist film PH as a mask to partly remove the Mo layer **15**B**3** and selectively remove the Al layer **15**B**2**, as shown in FIG. **18**B. Then, dry etching with chlorine gas is performed to selectively remove the Ti layer **15**B**1**, as shown in FIG. **18**C. This step makes the surface of the Ti layer **15**B**1** partly expose itself, thereby forming the wider part W, as shown in FIG. **15**. Finally, the photoresist film PH is removed. In this way it is possible to form the contact part **15**B at the same level as the wiring layer **15**A and to form the auxiliary wiring **15**C integrally with the contact part **15**B.

The thin film transistor Tr, the contact part **15**B, and the auxiliary wiring **15**C, which have been formed as mentioned above, are coated with the protective insulating film **16** and the planarized insulating film **17**A as shown in FIG. **19**A in the same way as in the first embodiment, so that the tapered opening (indicated by P**1**) is formed.

The planarized insulating film **17**A (with an opening formed therein) and the contact part **15**B are coated with the metal layer **18** in the same way as in the first embodiment, as shown in FIG. **19**B. Then, the metal layer **18** undergoes selective etching by photolithography, so that the first electrode **18**A (corresponding to each thin film transistor Tr) is formed as shown in FIG. **19**C.

After the first electrode **18**A has been formed, the electrode insulating film **21** is formed on the planarized insulating film **17**A and the first electrode **18**A as shown in FIG. **20**A in the same way as in the first embodiment.

After the electrode insulating film **21** has been formed, the first electrode **18**A is coated with the organic light-emitting layer **19** by vacuum deposition, as shown in FIG. **20**B. Then, the second electrode **20** (about 10 nm thick) is evenly formed by vacuum deposition on the organic light-emitting layer **19**, the electrode insulating film **21**, the planarized insulating film **17**A, and the contact part **15**B.

Finally, the second electrode **20** is evenly coated by CVD with a protective film (not shown). The protective film (not shown) is evenly coated by drop injection with the sealing resin **17**B, so that the above-mentioned constituents are held between the transparent substrates **10**A and **10**B. In this way there is obtained the organic EL display device **1** according to this embodiment as shown in FIGS. **14** and **15**.

The organic EL display device **1** produced by the above-mentioned process was tested for contact resistance between the first and second electrodes in the same way as in the second embodiment. The results of the test are shown in FIG. **21**. It is noted that the identical results are obtained from the structure shown in FIGS. **16**A and **16**B (the third embodiment) and the structure shown in FIG. **11** (the second embodiment). In other words, the auxiliary wiring **15**C which has the same laminate structure as the contact part **15**B and is formed integrally with the contact part **15**B further reduces contact resistance between the auxiliary wiring **15**C and the contact part **15**B and prevents the contact resistance from substantially increasing.

This organic EL display device **1** operates in the same way as the one according to the first embodiment. That is, upon application of voltage to the first electrode **18**A through the wiring layer **15**A and the thin film transistor Tr, the organic light-emitting layer **19** emits light with a luminance proportional to electric potential difference between the first electrode **18**A and the second electrode **20**. Light from the organic light-emitting layer **19** is reflected by the first electrode **18**A and then passes through the second electrode **19**. Therefore, it emerges upward from the transparent substrate **10**B shown in FIG. **4**. Thus, the organic EL element (EL) in each pixel, which emits light in response to pixel signals, produces a desired image in the organic EL display device.

This organic EL display device **1** is constructed such that the auxiliary wiring **15**C has the same laminate structure as the contact part **15**B and is formed integrally with the contact part **15**B. Therefore, it has a much smaller contact resistance between the auxiliary wiring **15**C and the contact part **15**B. This leads to a further reduction of contact resistance between the second electrode **20** and the auxiliary wiring **15**C.

As mentioned above, the third embodiment produces not only the same effect as the first embodiment but also the effect of further reducing contact resistance between the auxiliary wiring **15**C and the contact part **15**B, the latter effect being due to the fact that the auxiliary wiring **15**C has the same laminate structure as the contact part **15**B and is formed integrally with the contact part **15**B. This leads to further reduction of contact resistance between the auxiliary wiring **15**C and the contact part **15**B, which contributes to low power consumption and improved display quality.

MODULE AND APPLICATION EXAMPLES

The display device according to the above-mentioned embodiments can be used in various forms for television sets, digital cameras, notebook personal computers, portable telephones, video cameras, etc. which are equipped with a display device to produce images from external or internal signals.

Module

The display device according to any of the above-mentioned embodiments may be used in the form of module shown in FIG. **22** which is built into various electronic devices listed in the following application examples. The module shown in FIG. **22** is composed of a substrate **11**, a sealing substrate **50**, an adhesive layer **40**, and a region **210** extending from the sealing substrate **50** and the adhesive layer **40**. The region **210** contains a wiring for the signal line driving circuit **120** and the scan line driving circuit **130**, the wiring having an external terminal (not shown) being connected to a flexible printed circuit **220** for signal input and output.

Application Example 1

FIG. **23** is an external view showing a television set to which is applied the display device of the above-mentioned embodiments. This television set has an image display screen **300** including a front panel **310** and a filter glass **320**. The image display screen **300** is based on the display device according to the above-mentioned embodiments.

Application Example 2

FIGS. **24**A and **24**B is an external views showing a digital camera to which is applied the display device of the above-mentioned embodiments. This digital camera has an illuminator **410**, a display unit **420**, a menu switch **430**, and a shutter button **440**. The display unit **420** is based on the display device according to the above-mentioned embodiments.

Application Example 3

FIG. **25** is an external view showing a notebook personal computer to which is applied the display device of the above-mentioned embodiments. This personal computer has a main body **510**, a keyboard **520** for input operation, and a display unit **530** for image display. The display unit **530** is based on the display device according to the above-mentioned embodiments.

Application Example 4

FIG. **26** is an external view showing a video camera to which is applied the display device of the above-mentioned embodiments. This video camera has a main body **610**, a lens **620** attached to the main body **610**, a start/stop switch **630**, and a display unit **640**. The display unit **640** is based on the display device according to the above-mentioned embodiments.

Application Example 5

FIGS. **27**A to **27**G are external views showing portable telephones to which is applied the display device of the above-mentioned embodiments. This portable telephone is composed of an upper enclosure **710** and a lower enclosure **720**, which are joined together with a hinge **730**. It has a display **740**, a subdisplay **750**, a picture light **760**, and a camera **770**. The display unit **740** or the subdisplay **750** is based on the display device according to the above-mentioned embodiments.

The present invention has been described above with reference to the specific embodiments. However, it may be variously changed and modified without restrictions within the scope thereof.

For example, the contact part **15**B or **25**B may be formed at the level of other layers than the wiring layer **15**A or the first electrode **18**A and the auxiliary wiring **18**B, shown in FIG. **4**.

In the first embodiment, the auxiliary wiring **18**B is formed at the same level as the first electrode **18**A, and in the third embodiment, the auxiliary wiring **15**C is formed at the same level as the wiring layer **15**A and the contact part **15**B. However, the auxiliary wiring **18**B or **15**C may also be formed at the level of either layer. In addition, the auxiliary wiring **18**B and **15**C may be in combination and may be connected to each other through contact holes, so that when one auxiliary wiring breaks, the broken one is backed up by the other one.

In the above-mentioned embodiments, the electrode insulating film **21** has an opening (corresponding to the contact part **15**B) which is wider than that of the planarized insulting film **17**A thereunder. However, the opening of the electrode insulating film **21** may be narrower than that of the planarized insulating film **17**A so long as it has an upwardly expanding tapered shape.

In the above-mentioned embodiments, if the planarized insulating film **17**A and the protective insulating film **16** are formed separately, it is desirable that the planarized insulating film **17**A be placed inside the protective insulating film **16** of the contact part **15**B. However, this is not necessarily limitative.

In the second embodiment, all the films formed in the steps of forming the thin film transistor Tr are left as the lower layers of the contact part **15**B; however, it is not always necessary to leave all the films but some films may be removed, or an additional film separate from the thin film transistor Tr may be formed.

The display device according to the present embodiment may include not only the organic EL display device with an organic EL element as explained in the foregoing embodiments but also any other display devices.

The constituents in the foregoing embodiments are not restricted in material, thickness, forming process, and forming conditions to those specified above.

The organic EL display device **1** according to the foregoing embodiments is not always required to have all the layers mentioned above. In addition, it may also have an additional layer, such as a color filter layer attached to the transparent substrate **10**B.

It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

What is claimed is:

1. A display device having (a) a plurality of driving elements and (b) wiring parts electrically connected to said driving elements, the display device comprising:

a plurality of first electrodes respectively corresponding to each driving element on said driving elements and said wiring parts;

a plurality of light-emitting parts on said first electrodes;

a common second electrode, comprising a material that transmits light from said light-emitting part, said common second electrode on said light-emitting parts;

auxiliary wiring parts formed at the same depth level of the first electrodes and in a region between the first electrodes, the auxiliary wiring parts having a lower resistance than said second electrode; and

contact parts in a laminate structure including a plurality of conductive layers, the contact parts electrically connect said second electrode and said auxiliary wirings,

wherein,

at least the lowermost conductive layer of said conductive layers of said contact parts being in direct contact with said second electrode, and

the uppermost conductive layer of said conductive layers of said contact parts is in contact with said auxiliary wiring part.

2. The display device as defined in claim **1**, wherein:

said auxiliary wiring parts are formed in the region between said first electrodes from the same material as said first electrodes.

3. The display device as defined in claim **1**, wherein said wiring parts have the same laminate structure as said contact parts and are formed integrally with said contact parts.

4. The display device as defined in claim **1**, wherein said contact parts are of double-layered structure having the second conductive layer on the first conductive layer, and the first conductive layer is wider than the second conductive layer, and the second electrode is in contact with the wider part.

5. The display device as defined in claim **4**, wherein said first conductive layer is a metal layer of any of Ti, TiN, Al, Mo, W, Cr, Au, Pt, Cu, ITO, IZO, Ag, and alloys thereof.

6. The display device as defined in claim **5**, wherein said second conductive layer is a metal layer of Al.

7. The display device as defined in claim **1**, wherein said contact part is formed from the same layer as the wiring part of said driving elements.

8. The display device as defined in claim **7**, wherein an insulating film close to said driving elements and a film including a metal film are formed under said contact part.

9. The display device as defined in claim **7**, wherein:

an insulating layer having an opening in the region corresponding to said contact part is formed between said contact part and said second electrode, and

said opening is formed in an upwardly expanding tapered shape.

10. The display device as defined in claim **1**, wherein the lowermost conductive layer of the conductive layers of said contact parts is formed from a material which exhibits a high etching selectivity for said first electrode.

11. The display device as defined in claim **1**, wherein the contact parts which are formed in the laminate structure from the plurality of conductive layers comprises a three-layered structure composed of a first conductive layer, a second conductive layer, and a third conductive layer.

12. The display device as defined in claim **11**, wherein the first conductive layer is a lowermost layer of titanium (Ti), the second conductive layer is an intermediate layer of aluminum (Al), and the third conductive layer is an uppermost layer of molybdenum (Mo).

13. The display device as defined in claim **12**, wherein the first conductive layer is wider than the second conductive layer and the third conductive layer.

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